The
SCIENTIFIC MONTHLY

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Contents

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Science and Technology

(From the Month's News Releases)

Brake Pedal

An extra-wide brake pedal extension for cars with automatic transmissions makes braking easier and faster. The brake is endorsed by accident prevention bureaus and is approved by car factories. It can be operated with either foot, and the wider pedal surface eliminates foot slippage. The pedal extension can be installed in less than a minute.

Plastic Well Screen

A butyrate plastic well screen permits water wells to be drilled in many areas where corrosion or incrustation makes the use of metal screens impractical. This screen does not shatter or corrode, and will resist most oils and greases. It comes in light-weight, 5-ft sections in diameters up to 4 in. It is said to be ideal for wells as deep as 200 ft.

Image Projector

Low-cost image projector helps to improve commercial, industrial, and fine art work while speeding and simplifying production. This precision instrument casts bright, sharp, perfectly scaled images of illustrations, photos, physical objects or color transparencies directly on the drawing table. With the image thus cast on any working surface, art can be rendered with direct application of any selected art medium to the projected image. The projector will enlarge or reduce more than four times. It is set up over a regular drawing table so that it is instantly available for use at all times.

Safety Ladders

A safety ladder may be rolled to the desired position, but as soon as it is stepped upon the casters automatically disengage making the ladder immovable. Rubber-tipped legs grip the floor for firm support. When the person steps off, the casters instantly and automatically re-engage. Aluminum-finished steel is used in its construction, and the non-slip step plates are made of reinforced expanded steel. The ladders are available in two-, three-, four-, and six-step models. The larger four- and six-step models are furnished with handrails, and a detachable, wire mesh basket is available.

Slide Rule

Pocket and desk slide rules are available in vinyl plastic that does not swell, warp, or stick. The slide rules are produced with either a basic Mannheim type scale, or trigonometric, logarithmic, and various combinations of scales. They are resistant to wear and abrasion, and all smudges of grease, ink, and fingerprints are easily removed with a damp cloth. They have smooth machined groove-and-tongue surfaces which provide uniform sliding action under a wide range of temperature and humidity conditions. Numerals and some scale indices are engraved and shown in red on the trigonometric and logarithmic scales.

Spot and Stain Remover

A twin package contains two different solutions for removing spots and stains. The first solution may be used on spots caused by oil, grease, wax, tar, gum tape, and paint. The second fluid will remove stains made by fruit, berries, ice cream, gravy, salad oil, and chewing gum. The twin removers may be used on any fiber not affected by water. They are noninflammable, odor free, and will not leave a ring.

Language Cards

Adults and children can learn French or Spanish with a series of card games. No previous knowledge of the language is necessary. The cards may be played as solitare or by 2, 3, or 4 persons. Five different games teach reading, writing, and pronunciation. The Spanish games include 10 different card decks and clear instruction books explaining exactly how to play and learn. The French consist of 128 illustrated cards and a clothbound book. The games carry a ten-day, money-back guarantee.

Canister Cap

Coffee cans may be opened with a small unit that converts the can into a canister. The unit is pressed into the top of the can, and the coffee may be poured into a plastic cap, which measures just a tablespoon. When the cap is secured, the coffee is kept vacuum fresh. The can adapter may also be used on large fruit juice cans.

Home Power Generator

In times of emergency, a home power generator will come on automatically when commercial electric power service is interrupted. The gasoline-powered device has a steady running capacity of 3000 watts, which is enough power to feed the necessary appliances in an average home.

Auto Wax

The first practical car polish of pure Carnauba wax is now available. Carnauba wax, the basis of most auto and furniture wax polishes, has previously required adulteration with softer waxes because its hardness made it impractical to apply. The formula for this new polish employs a solvent in which 100 percent Carnauba is reduced to a smooth fluid state. It then can be applied with ease and speed, and the solvent

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evaporates in use. The car is first cleaned with a non-oil base cleaner, and then the polish is applied lightly with a soft cloth. It is wiped dry without rubbing. To produce a longer-lasting finish, a second coat is applied over the initial one. The polish may also be used on furniture which has first been cleaned with a damp cloth. A one-pint can averages enough for three car waxings.

Precision Drawing Board

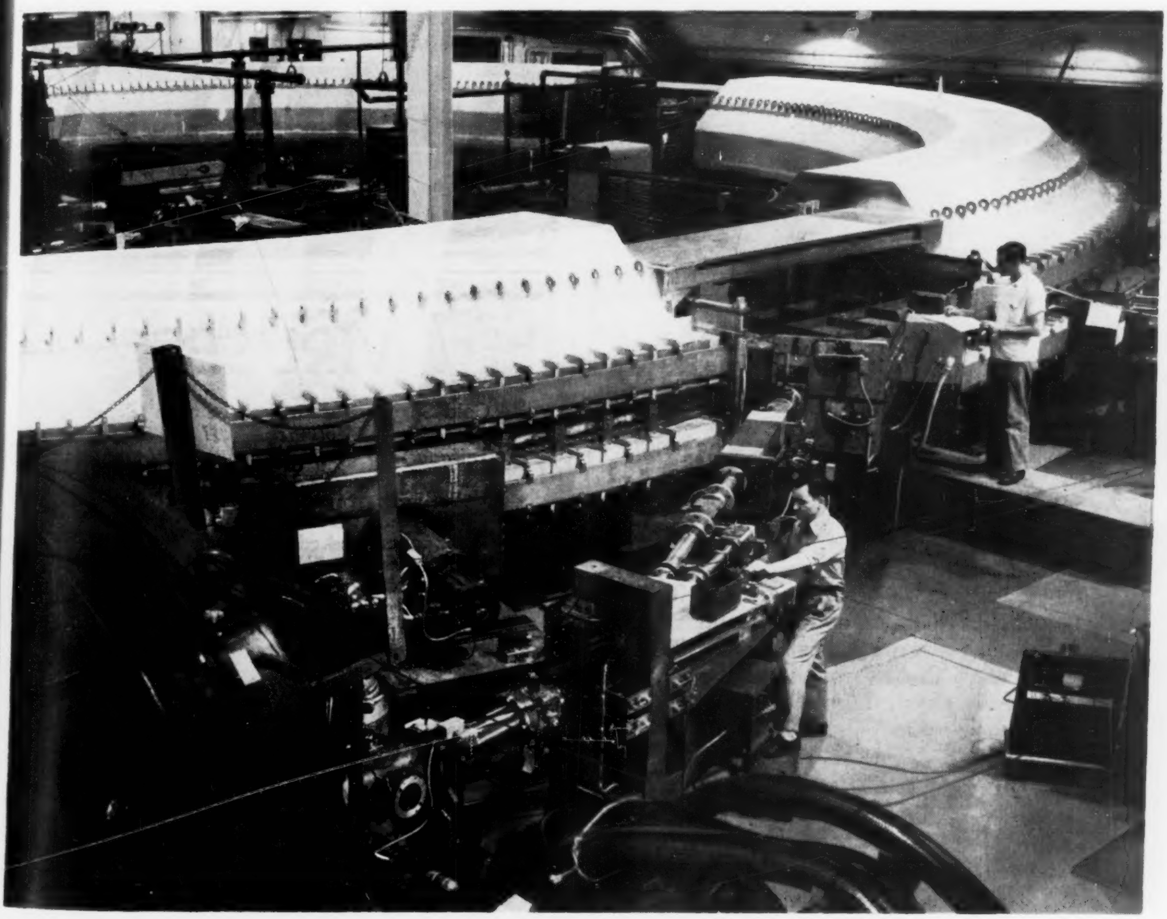
A portable drawing board of clear polystyrene plastic will be of use to anyone requiring a precision drawing, sketch, or design. It is made of durable, transparent plastic, and is small enough to be slipped into a brief case. Four corner clamps for attaching 8½″ × 11″ paper assure smooth, sure handling without the use of thumbtacks. A triangle or ruler can ride freely over the recessed clamps. Two metal straight edges, horizontal and vertical, are retractable so that precision work may be done without a T-square. Triangles may be stored under tension clamps beneath the board. The board measures 9¾″ × 12¼″.

Self-Focusing Magnifying Glass

A rectangular magnifying glass rests directly on the reading matter, eliminating the tiring task of holding the glass in the hand. The glass is self-focusing, and enlarges material to double size. It is extruded from transparent plastic into an H-shaped cross section in 3-, 6-, 9-, and 12-in. lengths.

Scissors Sharpener

Housewives can get the proper bevel on scissors right at home. A new sharpening unit may be used on all models from small sewing scissors to oversized kitchen shears. It is not necessary to take the scissors apart. The unit is mounted on a sturdy base and uses various grades of sharpening stones and files.



View of the Cosmotron at Brookhaven National Laboratory, Upton, New York, showing the equipment through which protons enter the machine. The steel tank (lower left) houses the Van de Graaff generator, which supplies protons at energies exceeding 3 million electron volts. Traveling through complex optical equipment, the proton beam enters the vacuum chamber of the Cosmotron. The giant "doughnut"-shaped magnet of the Cosmotron consists of 288 flat steel blocks 8 ft wide and 8 ft high, protected by white plastic coating. It is energized by a 40 million watt motor-generator unit. The magnet bends the protons in a circle so that they may be accelerated during each of their 3 million trips around the circle in one second. When the protons collide with atoms inserted as targets, the resultant fragments provide clues to the structure of the nuclei of atoms.

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JANUARY 1954

Geographic Influence of the Susquehanna Valley

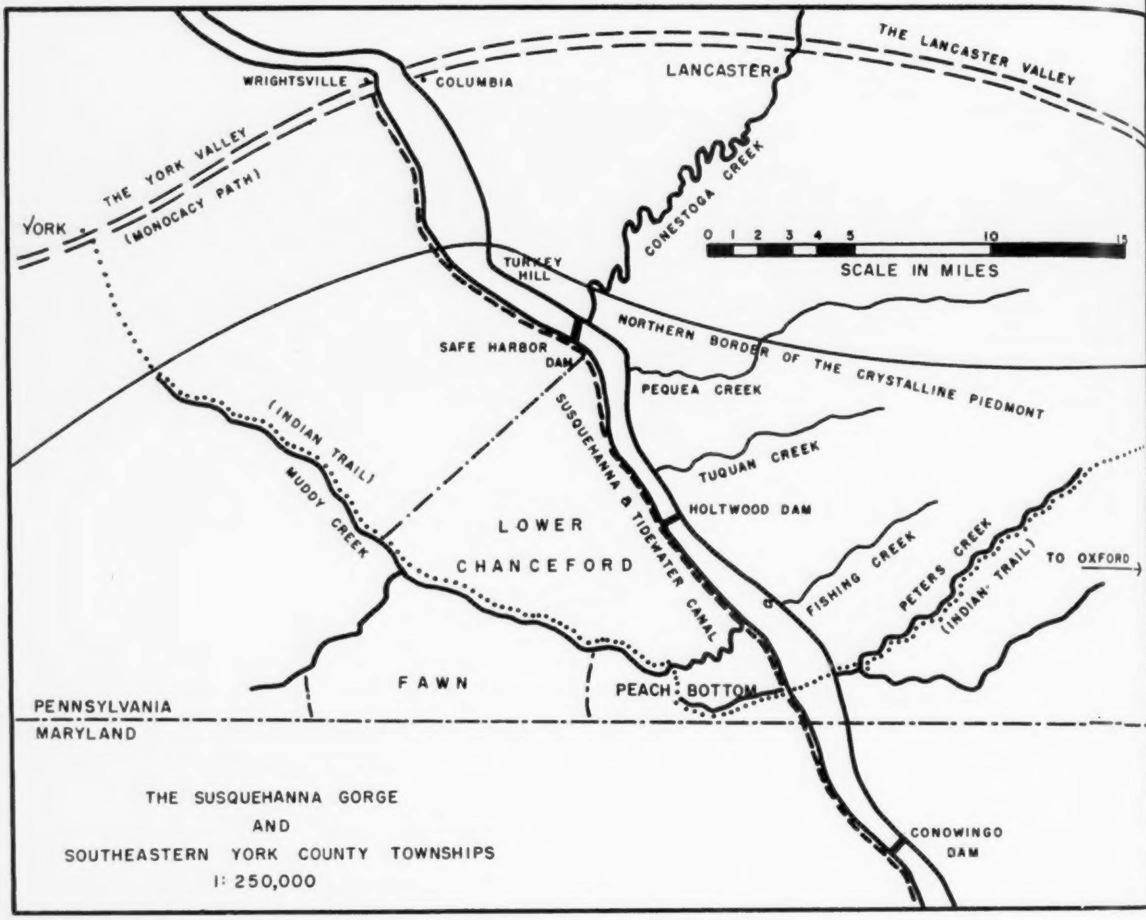
RICHMOND E. MYERS

The author was born in Bethlehem, Pennsylvania, and was educated in the Moravian schools of that community. He received his A.B. from Moravian College, his M.A. from the University of Pennsylvania, and his Ph.D. from Pennsylvania State College. After teaching in secondary schools, he taught geology and geography at Muhlenberg College, where he served as chairman of the Geology Department. He left Muhlenberg to become geologist for the Pennsylvania Water & Power Company of Lancaster, Pa. At present he is Chief of the Bureau of Industrial Research in the Department of Commerce of the Commonwealth of Pennsylvania.

THE area described in this study lies just north of the Mason-Dixon Line and directly west of the Susquehanna River. It comprises the southeastern corner of York County, Pennsylvania, embracing the township of Peach Bottom and portions of the adjoining townships of Fawn and lower Chanceford. Specifically this study is concerned with the string of communities lying immediately north of the Slate Hill ridge, which reaches southwest from the Susquehanna River to the Maryland line, a distance of about five miles. The problem involved is to analyze the factors that have been responsible for the economic development of this area and separate them into two distinct groups: first, the obvious local factors, and second, the less obvious regional ones.

For example, the Peach Bottom slate, which is the supporting formation of Slate Hill, was certainly an important element in the economic growth of the towns lying along its outcrop, such as Slate Hill, West Bangor, and Delta, in Pennsylvania, as well as Cardiff and Whiteford, just over the state boundary in Maryland. However, the slate was not the only factor responsible for the development of this corner of York County. It was the obvious one. It was local, and may have been the most important, or prime factor, but there have been more remote influences acting upon the region to produce the culturescape of today in Peach Bottom Township. These factors operated from outside the immediate area, hence they may be considered as regional rather than local. Many people living in the township may not have been aware of the influence these outside forces exerted in their lives. The most important of these regional factors was the Susquehanna River. In various ways it was as important in determining the economic pattern of southeastern York County as the slate. The river's significance lies chiefly in the fact that it has been a barrier from the first days of European penetration into its lower watershed. The Susquehanna could be crossed, but it was inconvenient to do so.

To analyze this situation let us look for a mo-



ment at the physiography of the lower Susquehanna Valley. From Turkey Hill, a few miles below Columbia, the river flows for forty miles through a deep, canyon-like gorge, which it has cut through the Piedmont. The walls of the gorge are precipitous and high, several hundred feet above the river in many places. Access to the river along this gorge is confined to the steep lower valleys of the Susquehanna's tributaries, such as the Conestoga, Pequea, Tucquan, Muddy, Fishing, or the Conowingo creeks on the eastern shore. Unless there was an adjoining valley leading west from the river on the opposite shore, these routes to the Susquehanna from the east served only as dead ends. Connecting valleys were few, the most important one being that of Muddy Creek in York County. River crossings by ferry were established at a number of these tributary junctions, but the most important ferry services were maintained north and south of the gorge, not in it. It is significant to note that from the first days settlers began moving inland from Philadelphia, but no through route developed leading west from the Susquehanna River south of the crossings above Turkey Hill, which marks the beginning of the gorge, nor is there any such route today.

As a result of this early isolation from the eastern part of Pennsylvania, although this territory was claimed by the Penns, prior to 1730 few Europeans settled on land west of the Susquehanna River in what is now York County. In 1721 Marylanders moved up from the Chesapeake Bay and surveyed the west shore country. Three years later Maryland authorities granted a tract of land along Muddy Creek to Thomas Larkin and Benjaman Tasker, which became known as "Solitude Tract." By 1739 a road connected the southern part of York County with the Chesapeake and by 1760 the region west of the Susquehanna had eight roads leading into Baltimore.[1] Thus we see that at a very early date the west shore country came into the economic sphere of Maryland interests. This continued after the Mason-Dixon Line was run and the boundary dispute settled, and it persists to the present day.

On the other hand, we find that as early as

1725, before Lancaster County was established, Thomas Johnson, the father-in-law of the famous or infamous Thomas Cressap, obtained a Penn title to the high island in the Susquehanna River that bears his name today.[2] He began operating a ferry soon afterwards. In time it became known as the Peach Bottom Ferry and continued in service until the building of the Conowingo Dam a quarter of a century ago. The location of this ferry was determined by the fact that several tributary valleys, those of Peters Creek and its tributary the Puddle Duck, lead down to the river in the vicinity of the island, through Lancaster County. On the opposite shore, several small valleys such as Wiley's Creek and the larger valley of Muddy Creek, all offered passage west. These more or less converged on the Susquehanna near the island. Muddy Creek pointed northwest. It was through the valleys of Peters Creek and Muddy Creek that a southern branch of the Great Minqua path gave the Indians a second route from the forks of the Brandywine to the Monocacy Path[3] which led through the York Valley. Where it crossed the Codorus Creek, the town of York was laid out in 1741. This path could easily have been one of those used by the Swedes in their early contacts with the Susquehannock Indians. It was certainly the route used (in part) at a much later date for the tracks of the Peach Bottom Railroad, which led to the Susquehanna River from Oxford on the east, and York on the west, but never crossed it.

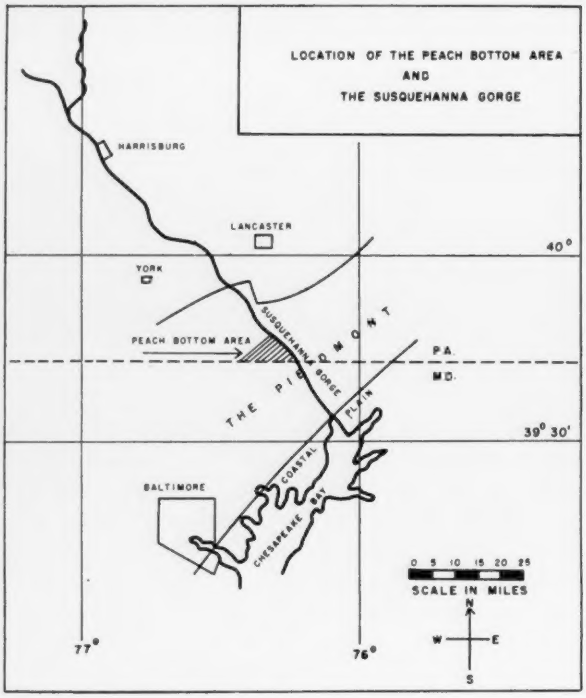
The southeastern part of York County was at an early date known as "the barrens." The soils of the area have never been as productive agriculturally as the Hagerstown loam in the rich limestone

The Susquehanna corridor to the Juniata Valley and the west. The Pennsylvania Railroad utilizes these watergaps in the first ridges of the folded Appalachians above Harrisburg to gain access to the Juniata Valley and an easy grade over the Allegheny Front behind Altoona. The Pennsylvania Railroad uses the bridge, longest stone arch railroad bridge in the world, to cross the Susquehanna River below the first watergap.

Typical Susquehanna riffles.

valley a few miles to the north. In the first wave of settlement west of the river, the Germans moved into the limestone areas, leaving the less desirable and more remote country for whoever wanted it. Into the hills of southeastern York County moved the Scotch-Irish, attracted perhaps by the country's possible resemblance to the old country across the sea, but more likely by its isolation. With them they brought their love of freedom and the Presbyterian faith. They also brought their liking for a good fight, and the fact that the land was in dispute between the Penns and the Baltimores and offered possibilities for some real fighting appealed to the Scotch-Irish temperament. It has even been suggested that they were deliberately planted here by the Penns to act as buffers against Marylanders moving north. Be that as it may, the first permanent settlers in this corner of York County did not come from the Chesapeake, but from Philadelphia, where they either secured their titles from the proprietors or came without title and became squatters. Between 1734 and 1736 a number of families took up land in this area and began farming it. In 1744 Alexander McCandless purchased the region around Delta from the Penns. These early settlers of course crossed the Susquehanna, but whether at Peach Bottom or farther north is not known.

Neither is it known exactly when slate was first quarried in this area. Local tradition claims slates were worked as early as 1750. Behre[4] reports that William Decker opened the first commercial quarry in 1785, but it is quite possible that some slate was worked before this date. No one living in the region could have been unaware of its presence. They may, however, have been unaware of its utility. In any case, quarrying did not develop as a major industry until about the middle of the last century. This may have been due to the fact that large markets were only then opening up for slate, with the tremendous growth of Baltimore



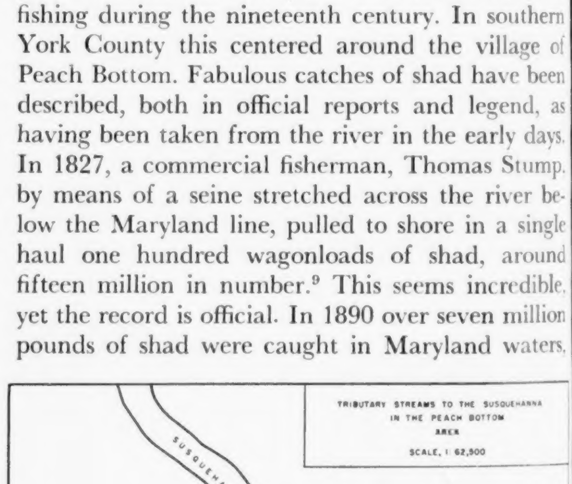
at this time. The river barrier played its part here. It effectively blocked movement of slate to the eastern Pennsylvania markets. Undoubtedly the opening of the canal up the west side of the river, giving the slate a smooth passage to the Chesapeake market, did much to help the industry. The canal was opened in 1840. As we shall note later, this canal was a part of another phase of the river's influence on the area's development.

By 1845 Welsh quarrymen were moving into the region from Wales, imported of course to work the slate. In 1850 Peach Bottom slate was awarded a prize at the Crystal Palace Exhibit in London. In 1858 Rogers[5] reported eighteen quarries working west of the river. To show how thoroughly the Welsh, in one generation, dominated the industry, note some names of quarry owners reported by Frazer[6] in 1880: William E. Williams & Co., John W. Jones & Co., Hugh E. Hughes & Co., W. C. Roberts, and E. Davies.

Another factor that played a major role in the opening of the region to outside markets was the construction of a railroad between Baltimore and York, which passed directly across the slate belt. It began operations in 1838. Both the railroad and the canal aided tremendously in the furthering of commercial relations with Maryland and tied the west river country more closely to Baltimore. They also brought about a general improvement in the agricultural picture of the area, by making possible the importing of large quantities of lime from the York Valley, resulting in improvement of the poor soils.[7]

At an early date efforts were made to cross the Susquehanna with adequate facilities to give the west shore hinterland outlets to eastern Pennsylvania. Numerous ferries operated across the gorge during most of the eighteenth and nineteenth centuries, some even into the present century. These were inadequate, both in size and frequency of service, and did little more than furnish local traffic a means of crossing the river. In 1815, and again in 1856, bridges were built across the river in the gorge. Both were destroyed by ice jams within a short time after they were opened to the public. The ice jams in the gorge were too much for the bridge builders of the nineteenth century. Another bridge had been planned to carry the Peach Bottom Railroad across the Susquehanna at Peach Bottom,[8] but this was never built. The urge to cross the river has always been present. It still exists. At the present time the people living on both sides of the lower Susquehanna River are keenly interested in a possible bridge which they hope will be built somewhere in the general vicinity of Holtwood.

Another local development, which was entirely associated with the river, was the commercial shad fishing during the nineteenth century. In southern York County this centered around the village of Peach Bottom. Fabulous catches of shad have been described, both in official reports and legend, as having been taken from the river in the early days. In 1827, a commercial fisherman, Thomas Stump, by means of a seine stretched across the river below the Maryland line, pulled to shore in a single haul one hundred wagonloads of shad, around fifteen million in number.[9] This seems incredible, yet the record is official. In 1890 over seven million pounds of shad were caught in Maryland waters,



Hydroelectric and steam plants at Holtwood, showing dam and lower gorge of the Susquehanna River.

but by that time the fish caught in Pennsylvania were insignificant. Shad fishing in the river reached its peak about 1830, and has been declining ever since.

Many reasons have been advanced for the decline of shad fishing. The most common complaint has been against the various dams that were built across the lower river for navigation improvement and hydroelectric power, yet it has been shown that the true reasons for the gradual disappearance of the fishing industry in the river were overfishing in the bay, destructive and illegal fishing in the river, the absence of any conservation measures, and selfish opposition to any such controls when proposed.[10]

A study was made from the records of the Maryland Department of Tidewater Fisheries. There are no obstructions in the Chesapeake Bay, yet it shows what happened to the annual run of shad from 1880 to 1946. The catch faded from a peak of 7,000,000 to less than 500,000 pounds.[11]

So much for the local scene. We now pass to the broader regional consideration of the Susquehanna Valley and its significance in the development of the southeastern corner of York County. Shortly after the Susquehanna meets York County soil, it encounters a series of three major systems of rapids, or riffles, the first at Middletown, the second at York Haven, and the third just above the mouth of the Codorus Creek. Ever since man began floating upriver products downstream, these rocky barriers lying athwart the course of the river rendered the Susquehanna unnavigable to anything except rafts, flatboats, arks, and similar shipping. These craft were able to come down only in periods of high water, and they were never able to move upstream. It is of interest to note that the first canal ever dug in Pennsylvania was constructed around the Conewago Riffles in York County in 1796. It was done in the hope that the dangerous passage, thus bypassed, would no longer block the lower river country to products from the north. However, the canal did not solve the problem. Most of the goods that came down the river until 1800 were landed at Middletown and transported overland in Conestoga wagons to Philadelphia via Lancaster. Now what does all this have to do with Peach Bottom, Fawn, and Lower Chanceford townships?

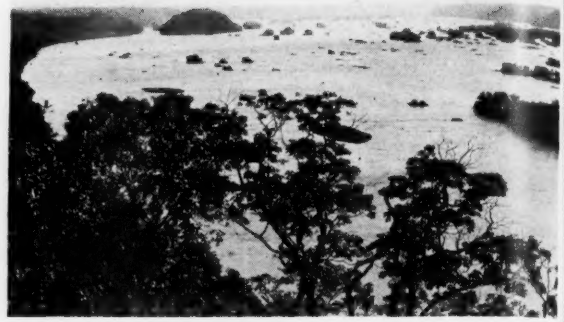
In the first place, Baltimore merchants did not like it. They felt their Chesapeake port was the logical receiving end of the trade and commerce of the Susquehanna watershed. As far as they were concerned, Philadelphia had no priority on the anthracite, lumber, or farm products that came down the river through the great gaps in the mountains north of Harrisburg. Baltimore capital did everything short of declaring war on Pennsylvania to divert this trade into Maryland. That is why the Susquehanna and Tidewater Canal was built, why a series of turnpikes radiated northward into the Susquehanna Valley from Baltimore, and why the Northern Central Railroad pushed its tracks almost into Sunbury. It is significant to note that whenever Maryland interests needed an act of the Pennsylvania Legislature to secure a charter for a canal or railroad, the opposition came from the Philadelphia members, and the support from

representatives of the southern Pennsylvania counties west of the Susquehanna River, as well as upriver counties.[12]

Now, what was the outcome of this struggle, and how did it affect the southeastern corner of York County? The answer to these questions is found in geography. All this Susquehanna trade over which the two cities contended was passing down what was essentially a north-south corridor. The valley of the Susquehanna River had thus been used for centuries. It gave the Indians a water route between the tidewater south and Canada. It was so used by the early white settlers, traders, and missionaries, who lived and worked in the watershed. However, the Susquehanna has ceased being used as a north-south corridor today and has become primarily an east-west route.[13] This change in emphasis has left the gorge portion of the valley in more or less complete isolation. No major highways follow the river here; in fact, no highways lead from Columbia or Wrightsville to the Chesapeake Bay along the river.

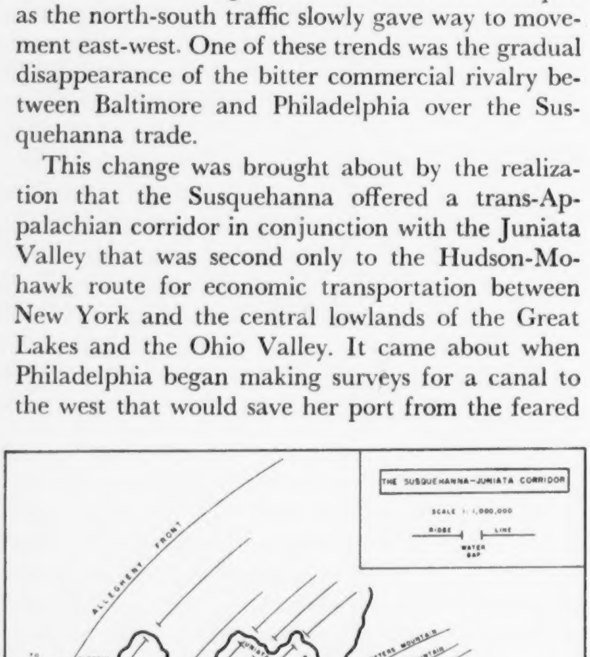
This change in corridor emphasis was responsible for a number of significant trends that developed as the north-south traffic slowly gave way to movement east-west. One of these trends was the gradual disappearance of the bitter commercial rivalry between Baltimore and Philadelphia over the Susquehanna trade.

This change was brought about by the realization that the Susquehanna offered a trans-Appalachian corridor in conjunction with the Juniata Valley that was second only to the Hudson-Mohawk route for economic transportation between New York and the central lowlands of the Great Lakes and the Ohio Valley. It came about when Philadelphia began making surveys for a canal to the west that would save her port from the feared



The lower gorge of the Susquehanna River, looking south, past Mount Johnson Island to the old Peach Bottom Ferry crossing. Note rocky nature of the river.

devastation that the Erie Canal was threatening to bring about. The Pennsylvania Canal showed the way, and the Pennsylvania Railroad followed, utilizing the three great water gaps in the mountains north of Harrisburg which led directly to the Juniata Valley and an easy crossing of the Allegheny Front near Altoona. Today U.S. Highway 22 parallels the railroad and the ruins of the old canal. These were, of course, all Philadelphia developments. Baltimore also backed the building of a railroad to the west, but in so doing she turned her back on the Susquehanna Valley trade.



One last question remains, how did this change of emphasis affect the southeastern corner of York County? The answer lies chiefly in the neglect of the lower river valley as a corridor. The canal, unable to compete with the railroads, slowly ceased to function, until it finally was closed. The only direct contact the west shore folk had left with their Lancaster County neighbors were inadequate ferries that one by one went out of business for lack of trade. The lower townships of York County continued to look southward for commercial and economic support, turning north only for political needs.

Then, with the turn of the century, came a new utilization of the gorge, in the building of the dams at Holtwood, Conowingo, and Safe Harbor, thus giving rise to the modern hydroelectric industry of the valley.[14] Here was an ideal spot to build dams without interfering with established land usage. No valuable fields had to be flooded, no large communities moved, no highways had to be relocated, and no hard feelings were brought about. Close by an expanding market for kilowatts, Baltimore and Philadelphia can now share in the twentieth century Susquehanna trade—electricity.

The present century has also seen a very significant decline in the slate industry of the area.

This has not been due to exhaustion of the slate, but rather to the rising cost of production and market competition with cheaper substitutes. Other difficulties that have tended to close the quarries have been the growing costs resulting from deeper quarry operations and the limited markets set up by transportation problems. Today's trend has been the use of the ground slate in the manufacture of roofing granules.[15] Whether or not this can save the industry is doubtful.

Agriculturally the area has turned toward poultry raising and dairy farming with quite some success, taking its place with the adjoining Piedmont Dairy Belt of Maryland and enjoying the Baltimore market for its products.

In a summation, the geographic factors that have played the major roles in the shaping of the regional economy may be placed in two categories. The local factors were: the slate, which served as an excellent resource in the past; the soils, which although not too well suited for crop agriculture, combined with the topography, which was too hilly for field land in many places, furnish an excellent environment for the dairy industry; and the gorge of the Susquehanna River, which was a barrier to the east, but furnished a north-south corridor. The second group, the regional factors were: the riffles in the Susquehanna River below Middletown, which, by diverting river trade to Philadelphia, set off the struggle between that city and Baltimore for the commercial control of the Susquehanna Valley; and the water gaps just north of Harrisburg that furnished access via the Juniata Valley to the west, thus creating an east-west corridor in the Susquehanna Valley, which superseded the north-south value of the river and isolated the lower gorge, leaving it open for the present century development of the hydroelectric industry.

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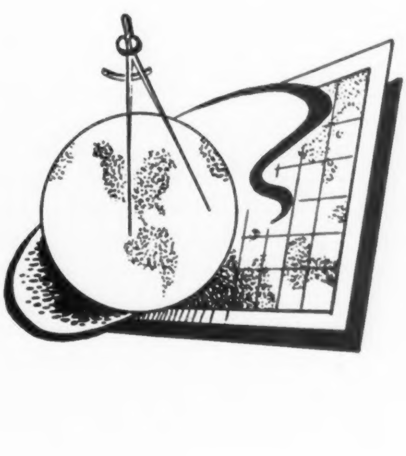

Order in Behavior

D. G. ELLSON

The author was born in Stafford, England, and received his A.B. from Miami University. He was trained as an experimental psychologist at Yale, where he received his Ph.D. in 1939. During World War II he became interested in what is known as human engineering, but which he prefers to call engineering psychology. He has since been carrying on research in this field for the Air Force and has been trying to apply frequency analysis and servo theory to human motor behavior. He is professor of psychology and chairman of the department at Indiana University.

A long time ago it was customary to ascribe a part of the behavior of physical things to metaphysical entities. The unpredictable aspects of the stars and the sea and the weather were attributed to some unknown design in the mind of the gods, or to their capriciousness. As knowledge of physical events under controlled conditions increases, this point of view is replaced by the notion that physical events are determined, and that any inability to predict physical phenomena perfectly in the field is due to our lack of knowledge of the determining states, or to inadequate theories relating these states to the variables to be predicted. Even the ammunition for the last stand of the metaphysicist, Heisenberg's principle, does not imply any metaphysical indeterminacy: it merely states that the required full knowledge of the determining states for certain elemental events is necessarily unobtainable.

Some remnant of the early metaphysical explanations of the unknown is still present in our language and our thinking about physical phenomena. We shake a stopped watch and say, "It doesn't want to run today" ("want" is certainly not in the scientific vocabulary of the physicist), and quickly abandon this terminology when the watchmaker relates the stopping of the wheels to the presence of dust. Engineers speak, facetiously of course, of "gremlins" as the cause of behavior of complex machines, which they cannot at the moment account for in terms of their engineering and scientific knowledge. It is a real part of our philosophical and linguistic heritage to give metaphysical explanations where our knowledge, our ability to state observed relationships, is inadequate.

As we have suggested, this philosophical heritage is largely disappearing today in the discussion of "physical" events. For these we have explanations that are more satisfactory than the metaphysical synonyms for unpredictability. But there is one class of physical events, namely behavioral events, for which our explanations are less adequate. There have been few scientific descriptions of even limited bits of behavior which do not leave a large residue of variability unaccounted for. Possibly as a consequence of this lack of knowledge, metaphysical determiners of behavior are still with us, though in mentalistic rather than theistic guise. In fact, not only are these metaphysical notions such as free-will and mind considered as possible "determiners" of behavior, but these unobservables and their determining function are also taken as self-evident facts by many scientists and laymen. A determination of behavior comparable in degree to the determination of physical events is often not even given consideration as a possibility.

This paper points to some evidence that the relationships between behavior and other observable events are not necessarily less exact than the relationships among nonbehavioral physical events. There is no way to demonstrate either determinacy or indeterminacy in any absolute sense. We can describe order: that is, we can make statements of relationships which we consider orderly and we can show the extent to which certain classes of data agree with these statements. But this agreement can be demonstrated only by means of observations, and so long as observation is subject to error, no matter how small, perfect agreement between a statement of absolute order and a set of observations is not to be expected. Since perfect agreement cannot be obtained, then the notion that behavior or any other class of events is completely determined (that is, completely orderly) becomes a matter of faith, at best an inference from a finite set of data obtained with a finite error of observation (personally, we have no objection to faith if it is recognized that faith implies uncertainty).

It is correspondingly impossible to demonstrate indeterminacy. The fact that a statement of orderly

relationship for a class of events has not been made, or if made, has not been shown to agree with empirical data, is in no sense proof that other such statements may not be made and verified in the future. The question becomes: to what extent is a class of events, in this case behavioral events, orderly? The question may also be stated: what proportion of the variability of behavior can be accounted for in statements of relationships with other observables?

Research data are not necessary to demonstrate that there is some order in behavior. The ability of parents, teachers, propagandists, and others to control human behavior implies correlation between behavior and other events. And there is no scarcity of research data that demonstrate *some* order in behavior by the simple process of rejecting the hypothesis of random (disorderly) association at a conventionally accepted level of confidence. The proportion of indeterminacy in these psychological data is often quite large. The error term representing discrepancies between empirically determined values and values obtained from any summarizing statement of relationship between the variables involved is often so great that the results of the research are reported only as a statistical association. If indeterminacy in data were equivalent to some "real" indeterminacy in the events observed, we might conclude that a considerable proportion of behavioral variability is indeterminate. But since there are many ways in which observation of a fully determinate set of events might give rise to indeterminate data, the conclusion is not justified. We do not equate ignorance of orderly relationship with its absence.

There are other examples of a very high degree of order in behavior. In many cases these are examples of close correlation between some aspect of behavior and a second variable, obtained when a number of other variables are held constant by experimental control or other means. Most of these examples are obtained under difficulty, as indicated by the rarity of the case or the painstaking scientific or artistic skill necessary to produce it. The infrequency of such high correlation in the absence of control and the apparent artificiality of the behavior or the situation when sufficient control is attained is sometimes presented as a basis for ignoring the correlation or for denying its relevance to the question of order in behavior. It might better be considered as an indication of the wide range of variables that determine behavior in the "natural state." The fact that the correlation is reduced or disappears when any one of many variables is not controlled is evidence that the controlled variables are also determining the behavior. If they were unrelated to behavior, nothing would be accomplished by controlling them. Therefore the degree of correlation that can be obtained under highly controlled conditions is not to be considered merely as a measure of the extent to which the behavior is related to a single variable. It is that plus an indication of the precision of determination by all of the variables which it was necessary to control.

It may not be amiss to point out that the exact correlations considered to be representative of physical science are seldom available for everyday inspection in nature. They also are relatively rare and difficult to produce in an observable form.

Some of the consequences of assuming indeterminacy of behavior are illustrated in quotations from the theoretical work of Hull. Hull's work is not selected as a poor example of psychological theory. Rather, it is one of the few examples of psychological theory in which basic notions are sufficiently explicit that an assumption of indeterminacy can be demonstrated in a single quotation.

The assumption of indeterminacy is quite clear in his postulate 10.

> Associated with every reaction potential ($S^{E}R$) there exists an inhibitory potentiality ($S^{O}R$) which oscillates in amount from instant to instant according to the normal "law" of chance, and whose range, maximum, and minimum, are constant. . . .

According to this statement and its context, spontaneous oscillation or variability is a characteristic of the organism. It originates within the logical boundaries of the organism. This oscillation represents variability of behavior which cannot be accounted for in terms of relationships with other variables, thus placing limits on the possibility of prediction. Hull recognizes this consequence of describing variability *as a characteristic of the organism* he is investigating rather than as a gap in his current knowledge, when he says:[1]

> With an intimate knowledge of the history of the organism in question and a good understanding of the molar laws of behavior, it should be possible to predict *within the limits imposed by the oscillation factor* what the subject will do under given conditions. That behavior prediction has this limitation may be disappointing to some . . . but there seems to be no escape from this difficulty; our task as scientists is to report what we find rather than what we or our friends might wish the situation to be. [The italics are Hull's.]

and

> Finally, it may be said that the principle of behavior oscillation is to a large extent responsible for the rela-

tively backward condition of the social, as compared with the physical, sciences.[1]

One who knew Hull can sense his personal disappointment in these words. He had come to believe that his theory (and all theories) of behavior must postulate a non-negligible indeterminacy in behavior, and he knew that this was a kind of confession of defeat. He has not said "This I do not know," but "This I can never know." To a scientist this is the admission that there is a blank wall blocking the end of an exciting road. Heisenberg's principle is one such wall. We may hope that Hull's glimpse of another wall much closer for the behavioral sciences was wrong.

One indication that Hull's pessimism was unjustified, as we have already suggested, is the existence of data showing behavior so highly correlated with observable variables as to be inconsistent with the picture of a spontaneously variable organism which Hull's theory describes.

Many examples of such high correlation are found in experimental studies of animal behavior, particularly in the work of Skinner and his students, who have emphasized experimental rather than statistical control of variables. However, since there are many who consider the demonstration of order in the behavior of animals to be unrelated to the question of order in human behavior, we have limited our examples to the behavior of men.

For some time experimental psychologists have been investigating the variables that affect visual brightness thresholds—the ability to correlate two responses "yes" and "no" with the presence and absence of dim flashes of light. Under adequately controlled conditions when the subject is instructed to respond "Yes" when he sees the flash and "No" when he does not, the light intensity associated with a "yes" is very low. The amount of light is appropriately described in quanta units. In measuring this "absolute" threshold, Hecht, Schlaer, and Pirenne[2] reported thresholds which fall between 5 and 8 quanta for different individuals. Because of the physical nature of light, it is impossible to obtain complete control over the amount of light (number of quanta) included in one of the flashes used as stimuli. However, since the mean number of quanta in the threshold stimulus is small, the statistical distribution of quanta in series of stimuli may be described as Poisson distributions. When this is done, it is found that the statistical distribution of "yes" and "no" responses given by the subjects agrees with the probability characteristics of the stimulus. As the authors point out, in this series of experiments the measured variability of behavior is completely accounted for in terms of the variability of the physical stimuli. There is no evidence for any significant biological variability.

Mueller performed similar experiments to determine the minimum increment of light intensity that can be associated with a change of response. In this case he describes stimuli as distributions of quanta whose means differ by the mean number of quanta represented by the increment.[3] With adequate control of other variables, the responses again agree so closely with the probability characteristics of the physical stimuli that there is no need to assume behavioral variability.[4] It would appear that the limits of prediction for a science of behavior are not necessarily different from those which Heisenberg describes for physics.

The degree of order in behavior which is represented in these examples can be appreciated if one reviews (or imagines) the precision necessary in the construction of a physical instrument that would demonstrate an equivalent correlation.

When human thresholds for sound have been determined as carefully as the visual thresholds mentioned above, it is found that verbal responses can be correlated with changes in air pressure so small that they represent the kinetic energy of a few molecules. Greater precision would have little practical value. It would produce differential responses to the continuous variations in pressure which result from the continuous motion of individual air molecules.

Threshold measurements such as these are often dismissed as of interest to physiologists rather than to psychologists. For some reason it is assumed that they are measures of the precision of the eye or ear alone. Since the eye and the ear are included in the chain of transmission from environmental to behavioral event, it is true that such data demonstrate the precision of these organs as components. But the data of the experiments are the relation between a physical stimulus and verbal behavior. They represent the performance of the man as a whole.

There are other data which indicate that precision is not limited to the sense organs as components. The accuracy of binocular vision, auditory localization, and other binaural discriminations implies a very high precision for functions which clearly depend upon comparison of data transmitted from structurally independent sense organs.

All the evidence that behavior may be related in a very orderly way to observable events does not come from the laboratory. Many examples may

be taken from the arts. The precision of coordination required of performers in the best professional ballet or symphonic production implies a very high correlation between environmental and behavioral events. A first-rate director of either of these performances will tolerate very little of the spontaneous variability that Hull describes in his oscillation principle.

Another indication of order in human behavior is the accuracy with which a chain of logical operations can be performed. For example, it is not unusual for a bright young student in the fourth or fifth grade of school to get a perfect score in ten successive tests in arithmetic. These scores are not necessarily accidental. They can be repeated under suitable conditions and can be predicted with some assurance.

In these school grades, problems of a complexity represented by $45678 \div 23$ are being taught, problems which can be solved in a minimum of ten steps by means of the arithmetic conventions of long division. Each of these steps or operations represents a response to marks on paper, all but the first of which (the printed problem or the teacher's blackboard version) result from the preceding response. For purposes of the computation below we shall assume that the ten steps are a set of ten stochastically independent trials with a constant underlying probability.

Let us make an estimate of the degree of order represented by the logical behavior of a ten-year-old, by the name of Johnny, in the fifth grade. We will assume that he has been given a series of ten tests in long division; each test was composed of ten problems with an average complexity equal to that of the one in the preceding paragraph. He solves only one of the 100 problems incorrectly, thus giving him an average score of 99%. This performance does not surprise his teacher, since it is in line with his previous performance in arithmetic.

In a sequence of operations of the sort represented by a long division problem, in which the answer will be incorrect if any single operation in solving the problem is not made in accordance with the arithmetic convention, the probability that the final answer will be correct is the product of the probabilities that any single operation was performed in accordance with the convention. With the simplifying assumption that these probabilities are equal for each operation, and ignoring the very small probability of exactly compensating errors within a single problem, then:

$$C = X^n \qquad \text{and} \qquad X = C^{1/n}$$

when C is the probability that the final answer to a problem is correct, X is the probability that each operation conforms to the arithmetic convention, and n is the number of operations in each problem.

From this equation we can determine that if Johnny receives a score of 99% on the set of ten tests, the probability that his response in each single operation conforms to the arithmetic convention is $0.99^{.1}$, or approximately 0.999. This is not an accident, it is a repeatable characteristic of his behavior. Although the concatenation of circumstances which produces such robot-like precision at the age of ten may be rare, it is sufficiently frequent that most of us have known at least one child who could equal Johnny's performance. And it is hoped that professionals do not have to depend upon chance to exceed it.

The figure 0.999 represents the probability that each of Johnny's responses will conform to the arithmetic convention during tests. But tests are commonly administered under working conditions which no professional logician would tolerate. They prohibit the use of one of his most effective technics for assuring maximum conformity. This technic is never described as a rule of logic, but logicians who design complex computing machines commonly incorporate it as a rule of their behavior. And if Johnny is bright enough to score 99% consistently in arithmetic tests, he is almost certain to discover this technic for himself, especially if conforming to the rules of arithmetic in writing homework papers carries any weight in determining his semester grades. This technic is to obtain two (or more) parallel and independent sets of computations, to compare them for any indications of difference in response at any point, and to take steps to remedy any nonconformity which such differences imply. The computations that Johnny compares with his own need not exceed, or even equal them, in the degree of original conformity. If his father can manage a score of 90%, this will be quite satisfactory.

Let us attempt to estimate the degree of conformity between the conventions of arithmetic and his own responses which Johnny can produce if he can average 99% on tests and if he compares his own computations with an independent set of computations produced by his father which are only 90% correct. In order to obtain this estimate we will make some simplifying assumptions:

1. The errors made by both father and son are all of one kind, namely, the substitution of one digit for another, and these substitutions, when they occur, are randomly distributed among the 9 incorrect digits. (To allow a wider variety of errors would increase the ef-

fectiveness of the technic, so that by limiting the number of classes of error to 9, we can only underestimate the final accuracy.)

2. There are no errors made in recognizing that a digit in one set of computations differs from the corresponding digit in the other.

3. When such a discrepancy is found, the error is corrected, that is, a new response which conforms to the convention can be substituted.

Under these conditions, the probability that the final set of long-division homework problems will contain an error is equal to the probability that both father and son make the same error at the same point in their independent computations.

$$\text{This probability, } D = \frac{(1 - C_j^1)\ (1 - C_f^1)}{m^2}$$

when C_j and C_f are the average test-scores of Johnny and his father respectively, and m is the number of classes of error.

The probability that a deviation from the arithmetic convention will remain in Johnny's homework paper if he follows the procedure we have described is (approximately):

$$D = \frac{(1 - .999)\ (1 - .99)}{81} = \frac{.00001}{81} = .000000114$$

This is one more example of the rather awesome precision that we find for behavior under certain conditions. It is perhaps worth pointing out that this last example describes the behavior of two interacting individuals. The precision represented in the performance of this small organized group suggests that even the social sciences may aspire to find something more than statistical associations among their variables. The methodological discipline which reveals this order in the behavior of living organisms is the subject for another and longer discussion, but one implication of the examples presented here is evident. There is no a priori reason to assume that the study of human behavior must necessarily be an inexact science. The variability of behavioral events that cannot be accounted for under ideal conditions is not necessarily different in magnitude from that which physical scientists have reported for simpler events.

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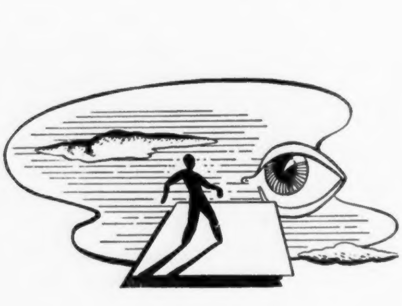


Germanium, a Secondary Metal of Primary Importance

ROBERT C. FITE

The author is a native Oklahoman and received his B.A. from Central State College (Oklahoma) and his M.A. from Oklahoma Agricultural and Mechanical College. After serving as a naval aerologist during World War II, he received his Ph.D. in geography at Northwestern University in 1951. He is now associate professor of geography at Oklahoma A. and M. College. Dr. Fite is chairman of the Geography Section of the Oklahoma Academy of Science, and State Coordinator for the National Council of Geography Teachers.

ONE of the least known metals of the earth is germanium, yet during the last decade it has skyrocketed from a laboratory curiosity to one of the most valuable metallic substances in existence. Primarily used in the field of electronics, it has permitted the construction of revolutionary devices that surely will improve the quality and performance of almost every piece of electronic equipment, from loud speakers to television sets to mechanical brains.

Germanium was first discovered by Clemens Winkler, a German scientist, in 1886. Its existence had been prophesied, however, fifteen years earlier by the scientist Mendelyeev, as necessary to complete the periodic table between silicon and tin. Dr. Winkler isolated germanium from the silver ore argyrodite and named it for Germany as the mineral gallium was named for France.

Germanium remained an insignificant metal for more than half a century. Traces of it were found in many parts of the world, but no concerted effort was made toward recovery because of lack of commercial demand. It was not until 1942, when the National Defense Research Council sought a semiconducting metal of high purity that germanium suddenly acquired commercial value. The discovery of its versatility in the field of electronics caused it to become five times as valuable as gold and incited miners and technicians to greater efforts toward its recovery.

Properties

Germanium is a metallic chemical element (symbol, Ge) with an atomic weight of 72.3. It is a grayish-white crystalline metal of great hardness and brittleness. Its melting point is 956° C (1750° F). Germanium may be alloyed with other metals but its known commercial uses require it to be in an exceptionally pure state. Less than one part per million of electrically active impurity is permissible in most of its applications. Strangely enough, however, these minor impurities are necessary for the desired electrical qualities and are added to the pure metal in controlled amounts. Germanium is stable at normal temperatures but readily oxidizes to become germanium dioxide (GeO_2) when heated to near its melting point in the presence of oxygen.

Occurrence

It has been estimated that there are from four to seven grams of germanium in each ton of the earth's crust, but no mineral has been found in which germanium is the principal component. Most of the ores, such as argyrodite, canfieldite, germanite, lepidolite, sphalerite, and tourmaline, containing it in significant amounts are also rare. Some germanite has been found in the copper-lead mines at Tsumeb, South-West Africa, but the occurrence is erratic and constitutes an unreliable source. Coal in England, the United States, and elsewhere has shown traces of germanium, as well as have the ores of tin, silver, iron, copper, and zinc from many parts of the world. At present, only two significant sources have been developed: coal flue dust of the Johnson Matthey and Company in England and flue dust from a zinc smelter of The Eagle-Picher Mining and Smelting Company at Henryetta, Oklahoma. The zinc ores of the tri-state district (Oklahoma, Kansas, and Missouri) offer the greatest current source of germanium and account for most of the world's production. The ores of the tri-state zinc area contain from 0.01 to 0.10 per cent germanium and

the estimated reserves from this source range up to twenty-four hundred tons of Ge metal.[1]

Production

In 1935, when germanium was found in a rather concentrated form in the flue dusts of the Henryetta zinc smelter, research began on a method of recovery, and the first germanium dioxide was produced in 1941. The original dioxide proved to be 99.9 per cent pure, but not pure enough, as later became evident when applied to semiconductor electronic uses. Cooperation between the federal government and the Eagle-Picher Mining and Smelting Company resulted in a pilot plant capable of producing germanium metal containing impurities of no more than one part per one hundred thousand. By 1948, annual production reached one thousand pounds of GeO_2, equivalent to six hundred ninety pounds of pure germanium. Production steadily increased to more than five thousand pounds of GeO_2 in 1951.[2] Even so, supply has continued to lag behind demand.

It has been reported that the Johnson Matthey and Company of England successfully began production from coal flue dust in 1950. There is probably also some production on the continent, but the entire European output is small, and the exact quantity is unknown.

Recent experimentation has revealed other possible sources of germanium. The 1951 *Minerals Yearbook* reports that small amounts are being produced by the American Steel and Wire Company, Donora, Pennsylvania, and the American Zinc, Lead, and Smelting Company will begin production very soon at Fairmont City, Illinois. The Omori plant of the Tokyo Gas Company has announced Japan's first production of germanium at the rate of about one hundred grams per day.

The processes for recovering germanium oxide from various industrial wastes require repeated operations of roasting, leaching, filtering, and distilling. The producing companies hold their exact technologies and production figures strictly confidential. Production of the metal in every case has remained a byproduct of minor importance and the geographic source of supply may shift materially with improved technology of recovery or discovery of new reserves.

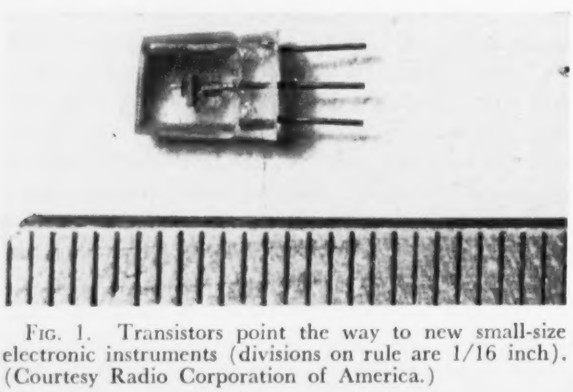


FIG. 1. Transistors point the way to new small-size electronic instruments (divisions on rule are 1/16 inch). (Courtesy Radio Corporation of America.)

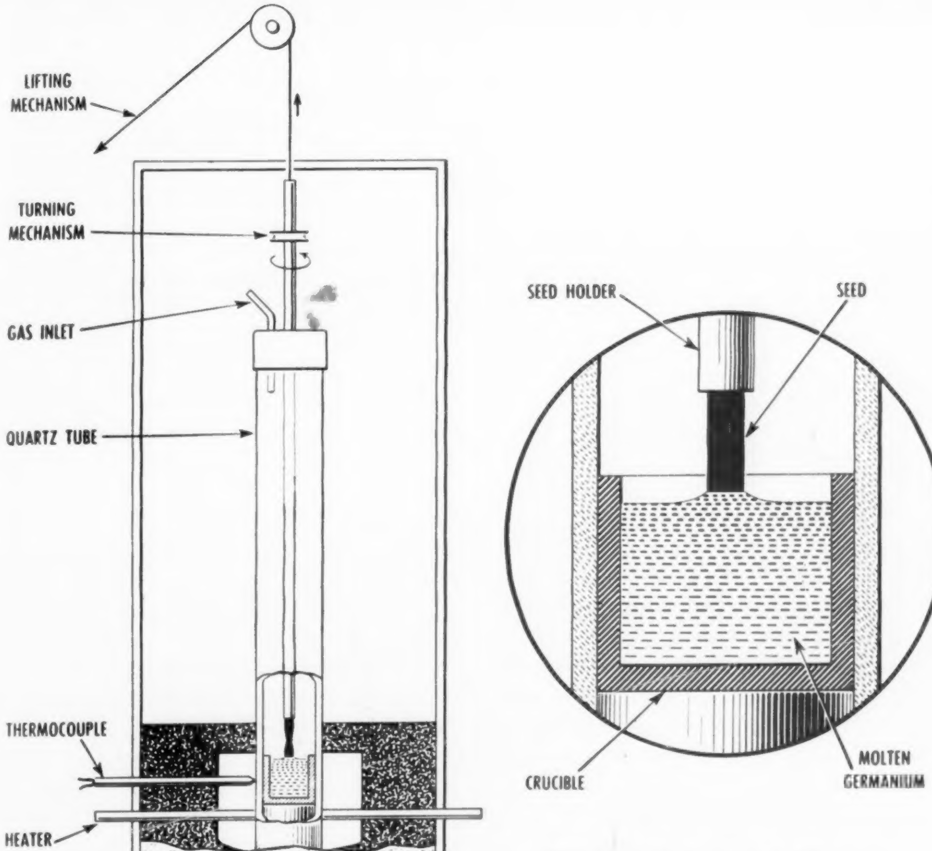
Uses

The remarkable electrical properties of germanium account for its mounting importance in the electronics field. It is neither a good conductor, as silver or copper, nor a good insulator, as glass, but under certain conditions it acts like copper and under other conditions like glass. A strand of germanium wire will permit the flow of electricity in one direction, but will resist its flow in the other. Even to those untrained in electrical technology, the possibilities become evident.

One of the first applications of germanium was in the construction of a rectifier to make alternating current unidirectional. This task has been performed by vacuum tubes in such modern appliances as amplifiers, radios, television receivers, and electronic computers. The size of the tubes, their cost, durability, and fragility largely determine the size and cost of the piece of equipment. The vacuum tube requires several seconds to react and constantly dissipates much heat energy while in use or merely standing by. The germanium rectifier requires the space of a large pea, can be mounted in an almost indestructible housing, gives off no heat, and reacts instantly on contact while using only one-tenth of the power of a vacuum tube. Because there are no parts to wear or burn out, the germanium rectifier has an estimated life of one hundred thousand hours of operation, about ten times the average life of a vacuum tube.

Already an improvement of the germanium rectifier has been developed in the more versatile device known as the "transistor." Developed by scientists of the Bell Telephone Laboratories in 1948, the transistor maintains all the desirable characteristics of the rectifier in addition to many new applications. Experimental results have proved its adaptability to numerous things for which the tube was not suited (Fig. 1). It should be understood, however, that the transistor is not interchangeable with the electron tube, but requires a complete new orientation and organization of the electrical circits in which it functions.

The Bell Telephone System is employing the transistor in its dialing mechanism to improve service at reduced cost. A current experiment, made possible by the transistor, in Englewood,



One type of apparatus for growing single crystals. Rotated seed is slowly withdrawn. Inset shows early stage as the crystal starts to form.

FIG. 2. Schematic cross section of a furnace for growing germanium crystals. Germanium crystals, from which transistors are made, are carefully grown from a "seed" on the end of a revolving shaft as it is slowly withdrawn from the molten metal in the furnace. (Courtesy Radio Corporation of America.)

New Jersey, is testing the feasibility of subscribers dialing their long-distance calls directly. The small size, instant reaction, and low power requirement of the transistor permit it to perform this task which is beyond the capacity of the vacuum tube. The typical transistor occupies about one-fiftieth of the space and requires about one-millionth of the power required by a small vacuum tube.[3]

The transistor has made many new devices possible; among them are portable television receivers, invisible hearing aids, improved electric eyes, and electronic brains no larger than an adding machine. Certain applications in the field of ultra-high frequencies, microwaves, military fire control, and communications are barely in the experimental stage and some are highly classified for security reasons. Others have not yet reached the developmental stage, such as the possibility of converting solar radiation into electrical energy and replacing the walkie-talkie with the "walkie-lookie." Among countless other things, this development has made feasible an efficient "wrist" or "pocket" radio that will operate from a single, small, low-voltage battery for hundreds of hours. In fact, it is believed that a radio can be devised that will operate solely from the heat energy dissipated by the human body.

Almost every electronics manufacturing company in the United States has begun experimental or mass production of germanium rectifiers and transistors. Some of the leaders in the field are Radio Corporation of America, Bell Telephone Company, Western Electric, Sylvania, and General Electric. About six million rectifiers were made in 1951 and extensively used in television receivers.[4]

It would be impossible to determine how much germanium will be required by the electronics industry if all the current promising experiments prove practical. On the other hand, it is probable

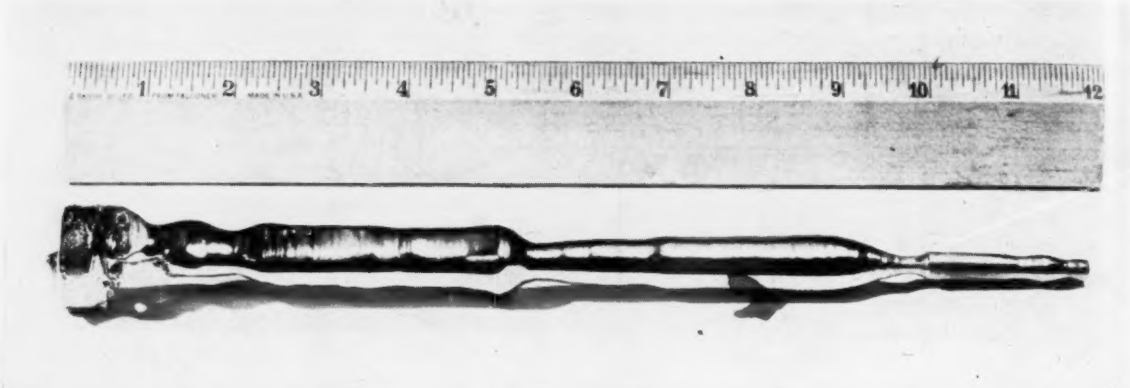


FIG. 3. Part of a single germanium crystal. By carefully operating the furnace mechanism, a single crystal can be produced that is several inches long. As many as 7000 transistors can be obtained from the crystal shown. (Courtesy Radio Corporation of America.)

that sufficient germanium can be produced to satisfy this demand because of the very nature of its uses. Usually, the manufacturer purchases germanium dioxide from the producer at about $140 per pound. Crystals of pure germanium are then grown in controlled furnaces from a "seed" slowly withdrawn from the molten metal which has been impregnated with impurities to create the desired characteristics (Fig. 2). The relatively high cost of germanium dioxide is of little consequence because of the small amounts required. Literally thousands of transistors may be made from a single crystal (Fig. 3). The final cost of the transistor is determined by the large amount of delicate and precision workmanship necessary to insure good connections and reliable performance.

In the newest types of transistors, thin slices of the germanium crystals are mounted in close proximity and connected to delicate wires. The crystals are so hard they must be cut with a diamond saw and so valuable that the dust is reprocessed into other crystals.

Outlook

The greatest limiting factors in the use of germanium at present are infant technologies and limited supply. In many cases the germanium product is in direct competition with the vacuum tube which has been developed and perfected over a period of thirty years. Some irregularities are yet to be corrected before the transistor can compete with the vacuum tube on even grounds. In many other instances, however, the transistor has already proved its superiority of performance. The development of positive (p-n-p) and negative (n-p-n) types have permitted complimentary, or reinforced, output from a single circuit that was never possible with the vacuum tube.

In most of the modern weapons of war electronics equipment has become indispensable, yet space is so critical in many of them that improved devices cannot be installed without redesigning the entire machine. Here the small transistor will prove invaluable and at the same time provide increased ruggedness and durability.

For the known uses of germanium, demands for its production will never be very great. More than three thousand transistors can be made from a single pound. Investigators have estimated that two thousand tons of germanium oxide could be produced annually from the coal ashes of Great Britain alone. There is little doubt that enough germanium can be produced annually from the world's known supply to provide adequate metal for the wildest expansion of the electronics industry.

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The Retreat from Heresy

FREDERICK C. NEFF

The author received his B.A. and M.A. from the Ohio State University. He completed the requirements for the doctorate in education at the University of California, Los Angeles, where he served as teaching assistant in the School of Education. He has taught in the public schools of Ohio and California. At present he is associate professor in the Department of Education at Occidental College, Los Angeles. During the past summer he was visiting lecturer in education at the University of Illinois. He has written numerous articles on educational theory, psychology, and philosophy.

FROM time to time the question of educational freedom erupts as a burning issue. That this is a period of such eruption is indicated by the professional "heat wave" currently being generated via press, radio, and lecture hall. The fund of literature on the subject of academic freedom is already great. It is not the purpose here simply to increase it. What is intended may be stated as follows: (1) to point out the need for a control of the theoretical basis of freedom as essential to an understanding of its practice; (2) to examine the functional ingredients of freedom with a view toward clarifying its theory; (3) to analyze what might be termed the conformity, heresy, and neutrality concepts of liberty in American education today; (4) to indicate the likely consequences attendant upon the present trend toward educational neutrality; and (5) to explore the possibility that a clearer understanding of educational freedom may emerge from a recognition of its kinship with the freedom of science.

Despite the current prominence accorded to discussions of freedom in education, the problem of defining the exact nature of the controversy, if not left dark, remains considerably beclouded. The fact that a sizable share of public opinion is not greatly weighted on the side of the professors is evinced by the popular use of the term "egghead" to denote derision of so-called intellectuals and academicians in general. This may be something more than just a side issue. It may, in fact, offer an opening wedge for a grasp of the problem.

I

There are two factors in the prevalent wave of anti-intellectualism that tend to place partial responsibility for it upon teachers and professors themselves. They may best be phrased as questions directed to the teaching profession as a whole. First, if the primary concern of American education is with liberty and democracy—as every reputable textbook in the field of education for the past fifty years has attested—why have educators displayed so little concern about curtailments of freedom in nonacademic areas and such sudden distress when their own private domain has been invaded?

Second, if an understanding of freedom is central to a democratic philosophy of education, why have there been such inconsistency and vagueness in articulating just what freedom means? Such confusion is still less excusable when it emanates from the education and philosophy departments of reputable colleges and universities. Nor does the contention that a free society fosters divergency rather than uniformity of belief substitute for a clear enunciation of the pivotal principle governing divergency.

It seems appropriate to raise the question whether educational freedom differs substantially from any other kind of freedom. Granted differences in application which the exigencies of any form of professional life demand, it seems only reasonable to hold that a clarification of freedom in principle ought to precede its practice in a special field of endeavor. To demand the right to practice a form of freedom which has not first been grappled with in theory is to confound privilege with responsibility. It is not to excuse the teaching profession to say that teachers and professors are practical people, if by "practical" it is meant that they need have no concern with or grasp of the controlling theory of freedom which is supposed to guide its intelligent practice. When the practical is not subordinate to the theoretical, the practical itself is likely to fail. Accordingly, a brief examination of the theoretical basis of freedom seems to be in order.

A sifting of philosophic concepts of liberalism reveals two elements which are indispensable in order for freedom to operate. These are power of choice, and power of action. On occasion attempts have been made to separate them and to regard freedom as all one or all the other. But a more

careful appraisal of these elements indicates that neither makes much sense without its complement. A man who is "free" to choose what kind of career he shall undertake, for example, may seem to be exercising his power of choice, and may to that degree appear to be free. But if there is no demand for the services of his proposed vocation; if he has not the available funds necessary to prepare himself adequately; if he lacks the knowledge required for any measure of success in his chosen field; if the economic or political structure of society is such that there is neither tolerance nor sustenance of his intended calling—in short, if he lacks the power to act upon his decision wisely—the choice itself can scarcely be termed free.

No man . . . can choose to do what he never heard of doing or never thought of doing. In this sense, the ultimate measure of freedom is knowledge and we learn in order to be free.[1]

On the other hand, no one was ever made free by the simple process of removing all external restraints. A person who is "free" to act may appear to have all the requisites of freedom. Yet, when action is separated from intelligence, when it ceases to be a culmination of reflection, when it is engaged in apart from a prior consideration of its consequences, when it is based on insufficient knowledge, such action is shackled by habit, or prejudice, or impulse, or ignorance, or any other constraining determinant which prevents it from being the fruition of a wisely initiated choice and, hence, from being fully free.

It will probably take the whole argument of modern scientists willing to enter the lists to show that all knowledge . . . makes for freedom, and that man cannot ever lose his own self by knowing more about the world in which he acts. But there is reason to hope that we may come at last to a kind of Socratic morality, after all our two millenniums of backsliding, and believe that knowledge and freedom are two adjectival aspects of the same good life, the same state of being. In such a development, of course knowledge will not be contemplation merely but practical knowledge that gives man help in action.[2]

Our present predicament is due more than anything else to the fact that we have learned to understand and control to a terrifying extent the forces of nature outside us, but not those that are embodied in ourselves.[3]

II

The foregoing is another way of saying that freedom requires the operation of both internal and external factors. Isolating the inner factor of intelligence from the outer factor of behavior results too often in the phenomenon of lopsided "scholars" and subject-matter specialists, whose training and outlook are such that they regard doing as inferior to knowing. These are the armchair authorities, whose concern is with contemplation, not action. They are more commonly recognized as formalists, classicists, and "intellectualists," for whom acting on things known is a desecration of knowing for its own sake. Their notion of freedom is accordingly limited to choice-making abilities, with no necessary implication that choice need eventuate in outward action.

Isolation of what is practiced from what is purposed means, on the other hand, a divorcement of doing from a consideration of intention. It breaks the continuity between goals and the means used to arrive at them. Such severance results in a setting up of methods for their own sake, which soon become confounded with principles and then substituted for them. It results in the phenomenon of "practitioners" and vocationalists, poll takers and "surveyors," statisticians and methodologists, whose thesis is that it matters not so much what is done so long as it is done efficiently. Their conception of freedom is limited to the removal of external restrictions in order that action may be unimpeded. These are the "busy workers" and "efficiency experts," whose great concern is with means, not purposes, and for whom the "know how" is more important than the "know why." The tendency to make the ritual of data-gathering an end in itself has led one observer to remark that, in matters of research, if we are not careful, we shall find what we are looking for.

In reality, gathering facts, without a formulated reason for doing so and a pretty good idea as to what the facts may mean, is a sterile occupation and has not been the method of any important scientific advance. Indeed facts are elusive and you usually have to know what you are looking for before you can find one.[4]

Actually free science, the free following of curiosity, has never been trivial, selfish or purposeless. The sober record of experience shows that the trained human mind, if you give it free play and a congenial climate, turns to deep and significant enterprises.[5]

III

Our discussion thus far has dealt with what might be called the *necessary* conditions of freedom, i.e., powers of choice and powers of action. The guaranteeing of such abilities through the formulation of proper safeguards comprises what might be called the *sufficient* conditions of freedom. We turn now to a consideration of what restrictions need to be placed upon freedom in order that it may best be realized. If it be granted that it is precisely certain forms of restraint which make

freedom possible, then the question is not whether guidelines are necessary, but what guidelines are best. Yet there persists a fringe of liberalists who have consistently attached themselves to the former position.

The case for individualism, for example, has suffered considerably because many of its champions have been of too "rugged" a stripe. They have tended to view any measure which restricts personal liberties as an encroachment upon private rights, regardless of its social merits. An individualism which divorces itself from the social fabric and which identifies freedom exclusively with private concerns neglects to consider that the very liberties it espouses are only those which a society guarantees. It requires no more than a cursory examination of our usual activities during the course of an ordinary day to remind us how dependent we are upon others in those activities which we habitually term free.

The problem, then, has to do with what restrictions best promote a continuous extension of freedom as distinguished from those which would ultimately destroy it. If thought and action are liberated only in so far as society provides for their liberation, then it follows that any conception of freedom short of chaos must necessarily be social in nature.

> . . . the technical term Freedom [defines] the social conditions in which there are enough normal choices of behavior patterns open to every person to allow for experiment, and change, and diversity, both in the successive experiences of individual persons and also among different persons in the group.[6]
>
> One measure of the freedom in any group is, like the measure of any other value, the number of members who enjoy it.[7]

This is to say that freedom is basically a product of associated living. Instead of some sort of "inalienable" right, guaranteed by virtue of birth, freedom is, on the contrary, the outgrowth of an evolving, refining, improving society. As better ways are found of living together, the concept of freedom needs to be reconstructed accordingly. But certain questions present themselves. How far and in what areas are individuals free to reflect and to act? What sort of restrictions shall be placed upon freedom in order that it not destroy itself? Answers tend to represent three rather distinct positions, which, for our purposes, may be classified in terms of conformity, heresy, and neutrality.

IV

Scholastic and classical traditions have made much of conserving the values of the past, to which it was thought that men should be made to conform. If the question was raised whether conformity was not a compulsion contrary to freedom, the answer was that there was liberty in law. The fallacy of the argument lay not so much in the pretension that conformity to law was necessary as in the ways in which law was defined. By and large, law has traditionally been conceived as divine (Christian supernaturalism), as cosmic (romantic naturalism and positivism), as emanating from "pure" Reason (rationalism), or as embodied in established institutions and constituted authority (institutional idealism).

The approach of traditionalists has been largely empirical, i.e., based on timeworn procedures and the collocated experience of the ages. But it has been empirical only in a restricted sense, for the experience it draws from has itself been of a nonexperimental variety. In other words, the "experience" which traditionalism assumed was only that which the traditional, prescientific framework made possible. Where there was "experimentation" at all, it was usually with new ways of confirming old "truths," rather than with prying loose the so-called truths themselves for purposes of scientific scrutiny. Accordingly, it is understandable why the medieval conception of learning was in terms, not of *in*quiring, but of *ac*quiring. When there was questioning at all, answers were derived either by appeal to Reason, or by resort to established authority, which actually amounted to much the same thing.

> Even in matters where there is no risk to faith and devotion, no one shall introduce new questions in matters of great moment, or any opinion which does not have suitable authority, without first consulting his superiors; he shall not teach anything opposed to the axioms of learned men or the general belief of scholars.[8]

The above statement, dated 1599, is fairly indicative of the medieval, prescientific educational outlook. It makes no pretense of justifying learning on any other basis than that of conformity to the status quo. Surely, we have come a long way since the Middle Ages, and we are fond of reminding ourselves that medieval practices simply would not be tolerated in twentieth-century America, where the concern is with cultivating in every learner, regardless of his intelligence, an ability to solve such problems as are commensurate with his capacity to do so, whatever that capacity may be. That all has not been sweetness and light in American education, that democracy is not itself a magic word for dispelling authoritarian evils, and that scientific findings can be strangely distorted in the

hands of the unscientific, is attested by the following pronouncement of only a few years back:

Ours are the schools of a democracy, which *all* the children attend. At least half of them never had an original idea of any general nature, and never will. But they must behave as if they had *sound* ideas. Whether those ideas are original or not matters not in the least. It is better to be right than to be original. What the duller half of the population needs, therefore, is to have their reflexes conditioned into behavior that is socially suitable. And the wholesale memorizing of catchwords . . . is the only practical means of establishing bonds in the duller intellects between the findings of social scientists and the corresponding social behavior of the masses. Instead of trying to teach dullards to think for themselves, the intellectual leaders must think for them and drill the results . . . into their synapses.[9]

Indoctrination apparently has its roots in the conviction that to be educated means to conform, in a passionate distrust of intellectual freedom and the inquiring mind, in an assumption that the best way to train inferior minds is to keep them inferior. Evidently effective learning is to be accomplished by denying lesser minds any opportunity for creativeness or originality through offering them instead a program weighted with dogma, slogans, "catchwords," and other substitutes for thinking. The fact that indoctrination can be smuggled in by way of the "back door" and even get by in the name of democratic education is a solemn reminder that until freedom and democracy begin to emerge as clearer concepts than they are, they will continue to serve as "covers" for all sorts of authoritarian, absolutist, and unscientific educational schemes.

If there is one conclusion to which human experience unmistakably points, it is that democratic ends demand democratic methods for their realization. Authoritarian methods now offer themselves to us in new guises. They come to us claiming to serve the ultimate ends of freedom and equality in a classless society. Or they recommend adoption of a totalitarian regime in order to fight totalitarianism. In whatever form they offer themselves, they owe their seductive power to their claim to serve ideal ends. Our first defense is to realize that democracy can be served only by the slow day by day adoption and contagious diffusion in every phase of our common life of methods that are identical with the ends to be reached and that recourse to monistic, wholesale, absolutist procedures is a betrayal of human freedom no matter in what guise it presents itself.[10]

V

Traditional education, with the ideal of conformity at its core, is apparently posited on two assumptions: first, the hypothesis that most individuals cannot think for themselves, and, second, that preserving the status quo through indoctrination is better than attempting to improve it through education. If it can be said that many people do not think for themselves, it could with equal assurance be said that whether and how they think depend in great measure upon what opportunities they have been afforded for exercising their intelligence. The circularity of the traditionalist's reasoning is that he appears to be satisfied with an educational scheme which is stifling to thought and is at the same time scornful of its non-thinking products.

Regarding the second assumption, the matter of indoctrinating young people into the values of the status quo, it seems only fair to require a prior examination of which values in the status quo are worth preserving and which are perverse to the point of discard. If our educational endeavor is at all related to the problem of progress, then attention needs to be given to the improvement of values, not simply to their perpetuation. And if we are to progress, then our educational system needs to be something vastly different from an assembly line which turns out standardized products of conditioned conformity. If society is not to get bogged down in the quagmire of mediocrity, then it had best pay some attention to its radicals, its heretics and its nonconformists, whose extraordinary bents might well be explored. If ". . . progress depends more on safeguarding the rights of heresy than on the protection of orthodoxy,"[11] then the teaching profession might not only tolerate wholesome deviations from the ordinary, but, more positively, actually encourage and promote them.[12]

It is doubtful whether anyone ever earned a respectable niche in history simply on the basis of conformity. It is of such stuff as intelligent originality, creativity, and inventiveness, born often of skepticism and doubt, that the greatest minds have been made. Yet, many a brave thought has been conquered too early by fear and left us the poorer indeed.

Our doubts are traitors,
And make us lose the good we oft might win,
By fearing to attempt.[13]

The risk of heresy is essentially the risk of greatness. If education is committed to the cultivation of raw capacities, there is a sense in which these capacities must remain raw. What "mute inglorious Miltons" might have realized their powers had education seen fit to recognize and cherish them, we shall never know.

The inventive mind is rare; or, at least, it has been rare in the circumstances of the past. We have no rea-

on for supposing that we can breed greater men and women by any known method of cultural eugenics. But it is also true that we have no way of knowing how many great men and women have been bred in the past and thrown away. Indeed, we know that the waste must have been prodigious.[14]

Nor is the only loss to potential heretics themselves, a point which John Stuart Mill reminded us of a century ago:

> . . . it is not the minds of heretics that are deteriorated most, by the ban placed on all inquiry which does not end in the orthodox conclusions. The greatest harm done is to those who are not heretics, and whose whole mental development is cramped, and their reason cowed, by fear of heresy. Who can compute what the world loses in the multitude of promising intellects combined with timid characters, who dare not follow out any bold, vigorous, independent train of thought, lest it should land them in something which would admit of being considered irreligious or immoral? . . . Truth gains more even by the errors of one who, with due study and preparation, thinks for himself, than by the true opinions of those who only hold them because they do not suffer themselves to think.[15]

VI

To delete from history its heretics and its radicals would be to deprive it of that rare quality known as independence of mind; it would be to leave only somber accounts of drab lives, steeped in the mire of tradition, routine, and habit.

> . . . prophets, mystics, poets, scientific discoverers, are men whose lives are dominated by a vision; they are essentially solitary men. When their dominant impulse is strong, they feel that they cannot obey authority if it runs counter to what they profoundly believe to be good. Although, on this account, they are often persecuted in their own day, they are apt to be, of all men, those to whom posterity pays the highest honor. It is such men who put into the world the things that we most value, not only in religion, in art, and in science, but also in our way of feeling towards our neighbor, for improvements in the sense of social obligation, as in everything else, have been largely due to solitary men whose thoughts and emotions were not subject to the dominion of the herd.[16]

> [Most men] will not face the logical and moral necessity that posterity shall not be made up of our friends but must be an unpleasant multitude of men in many ways unlike and hostile to ourselves.[17]

From Socrates and Jesus to Dewey and Einstein, the thinker has been the nonconformist, the critic, the rebel from established norms and the desecrator of comfortable habits. There is a lesson here which education has perennially ignored.

> The chief danger that the young encounter is not any temptation to radicalism, but the soporific of conventionality. They imitate us too much, not too little; alas, that so few of them are aware of our faults! The best policy is to increase the number of critical youth as fast as we can.[18]

> [We should] produce citizens who are open-eyed toward social needs, and not terrified at the costs of progress; citizens for whom life, whether of the individual or of the state, is not a repetition of even a worthy past; for whom success is not a mere adding of resource to resource, but an ever-living adventure in readjustment, a continuing participation with God in the creation of a better world.[19]

To change our schools from an uncritical, rigid, and backward-looking philosophy to one that is scientific, flexible, and progressive requires reckoning with a curious tendency of human nature. It is the temptation to cling to, romanticize, and perpetuate the familiar, and to view with suspicion and disdain whatever is novel or different. Perhaps the tendency to glorify "the good old days," "the old-time religion," and "the little red schoolhouse" is not so much an indication of genuine conservatism as it is a symptom of maladjustment to a world that has moved forward. If sheer candor were required, it might be a revelation to discover how many persons who demand a return to the past are primarily concerned with fostering uncritical and prejudicial habits of mind as the only sure way of perpetuating their own status.

> A satirist of education may some day make a major comic character of the mature man who remembers a highly admirable self, which he thinks was his own self in his school days, and who wants the school to make over his children in his own imagined image. He never was what he thinks he was, of course, nor are they what he thinks they are. But he, nevertheless, is a bar to progress because he wants the old framework preserved, the subjects of study, the hours of work, the methods of instruction, those all must be as he remembers them because he remembers with such affection the small person he thinks existed once and which he thinks those methods helped into something wonderful.[20]

> That the boys of today are very much like the boys of yesterday and that the schools have changed mostly for the better is difficult to prove and . . . never to be believed. And this is part, of course, of an ironic habit common to all the generations in their mature years. They urge the young to make the world over and make it better, but they cry out in agony over every change.[21]

Before change there must be controversy, and before controversy there need to be facts. The freedom to seek out and verify knowledge is the only ultimate guarantee that discussion about facts can lead to intelligent change. When the young are denied opportunity to participate in discussions of a controversial nature, we can scarcely expect

an adult generation that is equipped to grapple with the growing complexities of the problems they will inherit. To say that an issue is controversial is to say that it deals with a problem which admits of more than one solution. To solve a problem scientifically means to gather relevant evidence, to examine the reliability of the evidence, and to test out, in one way or another, proposed suggestions emerging from an examination of such evidence. It means, on the negative side, a rejection of the notion that answers to problems are predetermined, that they may be found lying about, ready-made, labeled "solution." In so far as our schools are seriously dedicated to the critical, problem-solving approach to learning, and to the extent that we are truly concerned with cultural improvement, there is bound to be controversy. Indeed, there is reason for making of controversial issues the very heart of the educative process.

> . . . let us make them the nuclear subject matter of education. Being controversial, they will of themselves have the spirit and figure of life. Being momentous to the community, they cannot fail to be momentous also to those members of the community who are teachers and pupils. The options they present are urgent.[22]

VII

To judge from the recent outpourings on the subject, the danger to educational freedom is the likelihood that teachers and professors will no longer be able to engage with students in discussions of a controversial nature. The importance of such a danger is not to be minimized, and the consequences it would entail are grave indeed. Yet, it is doubtful that the probability of such a state of affairs is the real danger. For one thing, the phenomenon of the curious mind, the desire to know, the right to question and to demand adequate answers—all part of our traditionally free and experimental way of life—is reasonable guarantee that discussions of conflicting points of view are inevitable. Short of destroying the very sinews of democracy, it is unthinkable to have a generation of uninquisitive, apathetic, and quiescent American parents and youngsters to whom so sterile a brand of education would be tolerable. It is equally difficult to envision a generation of educators so fearful that such terms as "agnostic," "communistic," "fascistic," "religious," "political," "radical," "scientific," and "pragmatic" would be deleted from their vocabularies.

What has happened is that discussions of ostensible and possible dangers to freedom have served rather effectively to cover up a more insidious and immediate danger from another sector. It consists precisely in the retreat to neutrality whenever the "going gets rough"; in the tendency to "present all sides," but withdraw from the fray; in the supposition that controversial issues can be taught on an "include-me-out" basis. Marshalling the forces of this threat are the "middle-of-the-roaders," who harbor the notion that middle courses entail no commitments; the "realists," "essentialists," and "objectivists," who believe that facts, apart from any specific framework of operations, perform "cute tricks" in the way of organizing and interpreting themselves; the "transcendentalists," "ivory-tower-dwellers," and certain religionists, whose preoccupation with "universals" is such that they cannot be bothered with the immediate, the specific, and the urgent, and to whom democracy is a mere temporal provincialism;* and the plain mentally lazy, who had rather take the nearer, easier road of parceling out detached bits of information than to roll up their professional sleeves, engage in some sober reflection, and assume a share of obligation for outcomes.

VIII

The delusion of neutrality is the delusion that freedom and progress are automatic, self-perpetuating, somehow guaranteed in the "scheme of things"; it underwrites the dictum that good will triumph over evil without any particular effort on the part of man. The problem with which we are faced had better be attacked more directly by examining the alternatives involved. Are we willing to relegate freedom to a role of competitor with authoritarian ideologies, all of which are to be viewed "impartially"; or is it to be recognized that it is only the framework of freedom which makes impartiality of discussion possible? In exposing freedom to possible extirpation, are we not, in ancient phrase, biting the hand that feeds us, or killing the goose that laid the golden egg? Moreover, is there any escape, in the final appraisal, from the burden of responsibility which any position demands? Does not even the rejection of a stand constitute in itself a moral undertaking.

> In the sphere of moral decision the very refusal to choose, since refusal has specific consequences, is itself a moral act. The fact is now generally realized that a declaration to do nothing is itself a statement of pol-

* According to Jacques Maritain: "The Christian religion is annexed to no temporal regime; it is compatible with all forms of legitimate government; it is not its business to determine which type of civil rule men must adopt *hic et nunc*; it imposes none on their will nor . . does it specify any particular system of political philosophy, no matter how general, such as that system [democracy] which occupies us at the moment."[23]

icy. In so far as the commitments of educators, scholars, and citizens have consequences for the determination of social issues, moral responsibility for things left undone, as well as for things done, cannot be escaped.[24]

If freedom requires power to choose and to act, can freedom survive where such powers are not exercised? Can one remain neutral and at the same time exercise choice? Is it possible to be committed to neutrality and likewise be free to engage in intelligent activity? If the answer is yes, then the only conclusion possible is that freedom, instead of constituting a positive moral stand, is, on the contrary, characterized by the lack of it, and requires no special commitment, either in principle or in practice. If, on the other hand, it is impossible to be committed to freedom and at the same time remain neutral, then the concepts of freedom and neutrality are irreconcilable. It follows, then, that when freedom collides head on with neutrality, a choice one way or the other has to be made. The question we are most concerned with here is to which of these viewpoints the educational profession is or ought to be committed.

There is a prevalent notion that the deliberate fostering of freedom among those who learn amounts to the cultivation of a doctrinaire liberalism, hence, to a kind of indoctrination. The thing which refutes such an argument is that when liberalism becomes doctrinaire it ceases any longer to be liberal. And the pragmatic fact that the only way to learn freedom is to practice it precludes any need—or possibility—of indoctrinating it.

One of the greatest tragedies that could befall America today is that its schools and colleges should take a position of neutrality on issues crucial to its survival. If we may remind ourselves that the caliber of education is best measured by the caliber of its products, it might be wise to examine the probable consequences of a neutral education versus those of a free education. Are we prepared to welcome a generation of young people who are committed to nothing save neutrality; who, being neutral, have no intention of identifying themselves with causes that are deemed to be right; and whose loyalties, being neutral, are lodged nowhere? Can education afford to be neutral where the values identified with freedom are at stake? Are not impartiality and objectivity, after all, not neutral values, but, rather, means for the formulation of values? Are they not the very method of freedom and science; do they not constitute a *specific* method; and are we not betraying their proper identification with science and democracy in labeling them neutral?

Sincerity demands a maximum of impartiality in seeking and stating the reasons for the aims and the values which are chosen and rejected. But the scheme of education itself cannot be impartial in the sense of not involving a preference for some values over others. The obligation to be impartial is the obligation to state as clearly as possible what is chosen and why it is chosen. . . .[25]

IX

If the issue under discussion were clearly seen, there would be little point in debating it. That it is not in proper focus is evinced by the top-to-bottom confusion which infests our educational structure. When top-ranking administrators are wedged into positions of neutrality because of the confused thinking of confused governing boards, we can scarcely expect straight thinking from the "rank and file" of teachers and students. Two recent instances may be cited as examples of what is meant.

That school superintendents had better not support so "controversial" an issue as world unity is indicated by the pressures exerted by the board of education in Los Angeles, resulting in deletion from the city schools of a program fostering world understanding through the study of UNESCO. That university presidents had better not take a stand on such matters as religion, economics, or medicine contrary to the accepted opinions of their boards of trustees is attested by the recent summary dismissal of the president of the University of Illinois. These are but two recent incidents, yet they stand in the long history of intimidations, pressures, and hostilities brought to bear upon the educational profession. The irony of the situation is that the educator in a purportedly free society is now being asked to foster a freedom which to himself is denied. In the face of the odds, it is little wonder that the retreat from heresy has in many instances become a rout.

In our attempts to combat totalitarianism we seem to be gradually coming around to an adoption of the same techniques—fear, humiliation, reckless accusation, and subterfuge—which are supposed to characterize the enemy. And when we have been duped into thinking that our arch foe is contained within the geographical boundaries of some foreign nation, the deception that is being practiced upon us will be just about complete.

> In our concern over what communism may do to democracy, we have overlooked what we ourselves may do to democracy under the stimulus of fear. Fighting fire with fire is an easy but misleading slogan which has betrayed more than one cause in the past. Challenged by authoritarianism, men begin to build an authoritarianism of their own; they tend to take on the mood and techniques of their opponents; they answer heresy-hunting with heresy-hunting; they become like the thing

they fight. That is what fear does to people. If the tactics of the Soviets succeed in inducing us to try to stamp out dissent and to measure loyalty by conformity, if they scare us into a denial of our historic goals, then they have maneuvered us into retreating from the field before the battle has even begun.[26]

There is abundant evidence . . . to warrant the contention that a mounting anxiety may lead a people to acts which deny to schools the freedom that must be theirs if what the people seek through their acts, the protection of their way of life, is to come to pass. A restricting education will not prepare individuals for a free world. Democratic purposes call for an education of democratic quality.[27]

X

It may appear superfluous to point out that the method of free, open, public discussion and criticism of ideas, so vital to democratic processes, is essentially the method of science. Principles thus evolved are the antithesis of those claiming to be sacrosanct, private, intuitive, or otherwise closed to public inspection and approval. Both science and democracy subscribe to the principle that values shall be free to emerge from competent inquiry and testing; whereas unscientific and totalitarian procedures would impose beliefs upon a people ready-made—that is, apart from the framework of experience, testing, and consensus. The fact that the method of freedom is essentially the method of science is more than mere coincidence. With precision of meaning it may be said that, just as there can be no true science without freedom, neither can there be true freedom without science. For experience attests that freedom of inquiry and freedom of criticism are the only means by which a free society can survive. To be scientific in the only meaningful sense of the word is to be critical minded. Herein lies the moral core of the scientific habit of mind.

The charge that science is immoral may be dismissed as too abnormal to merit serious consideration here. But there is a rather widespread belief even among intellectual leaders to the effect that science is neither moral nor immoral—i.e., that it is amoral. The reasoning back of this assumption apparently stems from the notion that science is identified exclusively with method, and, since methods per se may serve many ends—right or wrong, good or bad—that the scientific method itself is devoid of moral content. The fallacy of this sort of reasoning lies in an illicit attempt to separate means from ends, and to regard morality as contained solely in one or solely in the other. While scientific means of inquiry may on occasion lead to the discovery of a *disturbing* truth—one which requires a readjustment of older thought patterns and oftentimes the discarding of primitive beliefs—it could scarcely be said to yield a "bad" truth. The ways in which a scientific truth is used (or abused) may indeed be "bad"; but can truth itself be so labeled? The discovery, for example, that ours is not a geocentric universe was most disturbing to those who had constructed their astronomical, metaphysical, and religious systems on such a premise; in fact, the recovery from that blow seems far from complete, even yet. But can it be seriously claimed that suppressing such a truth would have been better than revealing it? Furthermore, if truth and knowledge are "goods" in themselves, as opposed to superstition and falsehood, by what twist of logic can the methods used for discovering them—the *active* phase of the knowledge process—be termed amoral?

On the other hand, to ascribe morality to any principle without recourse to the authority by which it is claimed to be moral would be to suppose that a principle could be either right or wrong in itself, and that the method used in arriving at it or evidence of its validity was either of no importance or irrelevant. There have been such principles before, and there are still such principles today. But they can scarcely be termed either democratic or scientific, let alone humane. The principle of the divine right of monarchs was one. The principle of racial superiority envisioned by Nietzsche and promulgated by Hitler was another. Whatever "evidence" there was to substantiate such principles was either illusory, or lacking, or drawn from myth and superstition, or manufactured for the occasion. Any principle which has not emerged from the hard crucible of experience or which fails to meet the test of practice can hardly lay claim to morality, for it cannot even be true.

[The first moral principle of science] is that all judgments are in the public world, in the open, where men's minds can try to agree, not in the arcanum of any single personal experience where any man can believe what he pleases. . . .

Another moral characteristic of scientific method . . . is that no judgments will be given as absolutes. All judgments will be not only open to any man's question but will be offered always with the expectation that they may be changed by time and greater knowledge.[28]

In brief, methods and principles are inseparable elements of the scientific-democratic process. If truth is more moral than untruth, then methods which yield truth, and knowledge, and wisdom are necessarily more moral than those which breed

falsehood, and ignorance, and bigotry. Thus seen, scientific method is basically a moral method, since its very purpose is to produce truth, and it is truth which makes men free.

XI

Thomas Huxley's remark that "it is the customary fate of new truths to begin as heresies and to end as superstitions" may serve to remind us that unless our thinking be disciplined in a grasp of the hypothetical, the tentative, and the postulational nature of the truth-idea, what was a truth for one generation can easily become a millstone for the next. This is another way of saying that there is no room in a free society for doctrines claiming the sanction of infallibility, perfection, finality, or absolutism.

> The absolute judgments that are judgments as to Reality, or Beauty, or the Good, and which by their nature claim to be universal are found by observation to be relative to their cultural location. That is, the judgments on absolute Truth of a Hinayana Buddhist, born in Chieng-mai and educated by the yellow-robed mendicants of his village temple, are Hinayana Buddhist. A grocer's son in Nebraska may claim similar, or competing, universality for the Presbyterian judgments of his family and cultural location, and they will be Presbyterian. But something discovered in a laboratory in New York and stated as an operational, tentative, "truth," will be true in precisely the same degree when tested in Chieng-mai or in Nebraska or anywhere else. The absolute is, in this sense, culturally determined, which makes it relative. The operational judgment is subject always to correction but not to any cultural difference. In this sense, the universal becomes relative and the operational the "universal."[29]

> The great obstacle to democracy, down to the present day, is the Platonic philosophizing which lifts purpose or values out of the realm of everyday living and places them where "operational" procedures cannot reach them. The center of any educational program which professes to be democratic must be the irreconcilable conflict between democracy and absolutism.[30]

What freedom of inquiry is to the scientist, freedom to learn must be to the student. If ". . . science can be used as one of the tools by which to establish the conditions in which human powers may realize human values,"[31] then the function of education is not far removed. To the extent that science is educational and education is scientific, both are concerned in the development of critical mindedness, clear thinking, and humane attitudes. More specifically, education

> . . . has the purpose of criticizing culture and changing it. In its high ranges, it has also the purpose of freeing men from slavery to the cultural necessities by which they live.[32]

> [Our educational task] is to bridge the present cleavage in our culture by remoulding the attitudes, and habitual reactions, with respect to moral standards, which have been nurtured by the doctrine of eternal verities. . . . [It is] to make the empirical attitude toward moral problems as natural and spontaneous as it has become toward those of engineering and agriculture.[33]

Lest the critical approach be misconstrued to mean placing exclusively in the hands of professional educators the task of deciding educational goals, it needs to be pointed out that education has also a reflective role. When education appropriates unto itself the job of directing the course of social affairs, it is guilty of the very thing it most decries on the part of other groups when they undertake to prescribe what shall be taught in the public schools, the colleges, and the universities. This does not in any sense imply that the professional educator should be reduced to the role of "public servant" or "hired hand," who is restricted solely to mirroring and transmitting the culture. Nor does it mean that, while criticism is conceded to education, such criticism should remain purely "academic" and not reach out into the world of affairs. It means that, as in every other sphere of public endeavor, dictation of policy gives way in the free society to persuasion in the public forum of discussion, where educational goals, like every other goal, deserve the chance to be heard, to be discussed, to be criticized, and to be judged.

If education has at times been guilty of divorcing itself from the social milieu, if educators have often cloaked their discussions in the protective wrappings of educational "professionalese," it should also be said that professional economists, politicians, scientists, and religious leaders have too often been guilty of the same narrow "professionalism." They have too long overlooked the need for speaking a common language among themselves, as well as for enlisting the friendly aid of the schools and colleges in helping to bring about a more integrated and mutually cooperative social order. However, there is encouraging evidence at present to indicate that business and industry are becoming increasingly interested in the "cultural equipment" of their personnel, instead of in just vocational proficiency. Business and industry are also supplying the schools and colleges with valuable information in the way of pamphlets, brochures, magazines, films, transcriptions, etc., designed to acquaint students with everything from factors to be considered in a choice of vocation to the structure of American economic theory. The important thing about all this is that the old dic-

tation-of-policy, "pressure-group" way of doing things appears to be yielding to the view that good public relations is a better, more enlightened method of promoting liaison between education and the industrial and professional world in a "multigroup" society.

. . . in a modern society, the school is so significant a part of the education of the citizen that it may be confidently asserted that no state is long secure nor will any social philosophy long endure where the vital, if not indeed the determinate, relations between public education and the social and political values of a people are ignored.[34]

There is a single strand, in a democratic society —and it is a precious strand—which gives meaning to the divergency that is politics, economics, religion, science, and education. It is the inviolable principle of freedom. When that principle is violated by any economic, religious, "scientific," or educational faction, the very freedom which makes divergency possible is threatened, and the faction unwittingly sets in motion its own destruction, for it cannot long be free to endure. Thus a free society, when it no longer concerns itself with the principle which enables it to be free—perhaps because it is too busy being "practical"—must ultimately lose that which it prizes most. And thus it is that, where freedom is at stake, no institution which professes to be democratic can ever afford to remain neutral.

XII

When "the tumult and the shouting dies," when the last heretic has been laid safely to rest, when we have grown weary of the platitudinous nothingness of neutrality, it may be that a new kind of teaching and a new kind of teacher will emerge. What will the new teacher be like? That we cannot exactly predict. But at least we know what we should like him to be. The new teacher will be a free teacher—free to engage in such discussions and activities as wisdom of choice and consideration of consequences will warrant. From such discussions and activities tentative conclusions will be free to emerge which are justified by the play of intelligence upon the widest evidence that is available. The new teacher will be the embodiment of a mind released from fear, prejudice, and dogmatism; his will be a freed and humane intelligence engaging in such activities as a kindled imagination can open up for human exploration.

The new teacher will employ techniques of instruction appropriate to the requirements of living in a world that is friendly to change. Because much of the insecurity of the past and present has been due to a forlorn attempt to fit fixed principles into a world that is moving rapidly away from their mechanistic counterparts, the biggest job of the new teacher will be to teach students how to live in a new kind of world—to teach them how to cope with problems that are yet to emerge in a world that is still in the making.

We need from the teacher who has relied on teaching how a tried method can be used on new material, a totally new kind of teaching—a teaching of a readiness to use *unknown* ways to solve unknown problems. We are facing a world which this adult generation is unable to grasp, to manage, to plan for. The most we may reasonably hope for is that somehow the old unsuitable methods will get us through until another generation is able to tackle the job. But throughout history, each generation has stood on the shoulders of the past, each new learning has come from an old learning, if only by way of contradiction and explicit rejection. How are we who do not know what to do, who do not know how to live in one world . . . who do not know how to carry in our hearts the weight of those who died yesterday in Burma or who may die tomorrow in Prague . . . how shall we, who are so unfit, prepare a generation which will begin to be fit to face the new problems which confront mankind? At first sight, it seems a hopeless dilemma, for men can teach only what they know. And yet it need not be, because what we need to teach is a technique which can perhaps be well communicated if we ourselves fully realize our own position. We need to teach our students how to think, when you don't know what method to use, about a problem which is not yet formulated. . . . So if we, who live now, can fully realize and incorporate into our every teaching word and gesture our parlous state, we will, as we transmit it to our pupils and students, give them just the freedom, just the sense of an unguessed-at process which nevertheless *must be found,* which, if they incorporate it, should equip them as no generation has ever been equipped to make the new inventions which are necessary for a new world.[35]

When the educator and the scientist realize a just share in the greatest freedom that tomorrow's world can afford; when deeds have demonstrated our respect for the sanctity of human individuality; when teachers, scientists, citizens, and scholars cease emphasizing their differences and begin pooling their resources; when our great, common dedication is to the continuous extension of a free and humane way of life; when the democratic ideal begins to emerge as a gospel to live by—then the end of the retreat from heresy, and the beginning of an adventure in liberty.

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MUENSTER APOTHEKE MORTAR

The mortar on the front cover came from the Muenster (Cathedral) Pharmacy of Freiburg in Breisgau, Germany. It is now in the Smithsonian Institution in Washington where it may be seen in a typical setting, the interior of a German pharmacy of the same period.

The mortar of bronze is on a finely carved wooden pedestal, German-Swiss, 1686. It is an example of the large Renaissance mortars which served more as decorative symbols for the pharmacy than for practical use. The pedestal of the graceful, semi-kneeling boy is carved of hard nut wood. The stand and mortar, together, are forty-five inches high. The inscription reads, when translated literally, "Sebastian Ertzberger orders me be cast by Heinrich Weitnauer in Basle, 1686."

[The collection in the Smithsonian Institution, of which the figure is a part, is described in *The Squibb Ancient Pharmacy,* prepared by George Urdang, in collaboration with F. W. Nitardy, Squibb & Sons, New York, 1940.]

Rockets and the Upper Atmosphere

HOMER E. NEWELL, JR.

Dr. Newell completed his undergraduate studies at Harvard College, and obtained his A.M. from the Harvard Graduate School of Education. In 1940 he was granted a Ph.D. in mathematics from the University of Wisconsin. He was a member of the Department of Mathematics at the University of Maryland until 1944. Since that time he has been a theoretical physicist and mathematician for the Naval Research Laboratory, and is presently Head of the Rocket-Sonde Research Branch.

MANY years ago scientists began to think of rockets as a means of performing experiments in the high atmosphere. An impelling motive behind Goddard's early rocket work, for example, was the desire to study the upper atmosphere at first hand. When F. J. W. Whipple first proposed a warm layer at the top of the ozonosphere to explain the bending of sound waves back to earth, he suggested that his hypothesis could be tested directly in one of Goddard's rockets. And when large rockets did become available as a result of missile developments during World War II, they were quickly put to work in studying the atmosphere.

Although one can assemble a long list of things that make it difficult to perform accurate experiments in rockets, still the possibility of bringing the measuring device into direct contact with the object of measurement is often the prime consideration. This possibility greatly facilitates the performance of a completely definitive experiment, whereas in studying the upper atmosphere from the ground a long chain of reasoning involving many assumptions and much speculation often lies between observations and conclusions.

After a half-dozen years of exploring the upper atmosphere with rockets, a number of things have been done which it was not previously possible to do. Without attempting to be complete, either in the listing of results or in the description of individual experiments, this paper seeks to acquaint the reader with some of the more important contributions of the rocket to upper air physics. The studies chosen for discussion are those which seem to require the rocket for their accomplishment.

Ozone and Solar Ultraviolet Light

From the surface of the earth one looks out upon the sun, stars, and planets through the atmosphere, which is transparent to visible light and to many of the longer wavelengths. In the ultraviolet and x-ray regions, on the other hand, the atmosphere is more or less opaque, and incident radiation below about 2900 A is absorbed before reaching the ground. To observe such radiation directly it becomes necessary to transport equipment above the absorbing layers, which in many case can be done at the present time only with rockets.

An example is furnished by solar ultraviolet light in the neighborhood of 2550 A, which is strongly absorbed in the upper atmosphere by ozone. Suppose that for the wavelength λ, $I_0(\lambda)$ denotes the intensity of sunlight above the ozone layer. Then at a specified point within the atmosphere, the intensity $I(\lambda)$ would be given by

$$I(\lambda) = I_0(\lambda)\ \exp.\ [-\alpha(\lambda)\ x(h)] \tag{1}$$

where $\alpha(\lambda)$ is the absorption coefficient for ozone corresponding to the wavelength λ, h is the height of the specified point above the surface of the earth, and $x(h)$ is the total amount of ozone between the specified point and the sun. Customarily $x(h)$ is expressed in centimeters of ozone at normal temperature and pressure, in which case $\alpha(\lambda)$ must appear as inverse centimeters. The absorption is strongest in the immediate neighborhood of 2550 A, but extends for several hundred angstroms in either direction from that wavelength. As the ozone layer is traversed in the upward direction, $x(h)$ decreases steadily, so that, for each wavelength λ, $I(\lambda)$ tends steadily to $I_0(\lambda)$. This effect is strikingly illustrated in the series of spectra shown in Fig. 1. The spectrograms, obtained by Tousey and colleagues in an Aerobee flight at White Sands, New Mexico, on June 14, 1949,[1] are arranged in order of increasing height, and show a progressive extension of the solar spectrum into

the shorter wavelengths as the amount of ozone between the spectrograph and the sun decreases. This extension of the known solar spectrum permits one to study the sun in hitherto hidden wavelengths.

One can use the series of spectra shown in Fig. 1 to determine the distribution of ozone with altitude. First, by photographic photometry the spectra are converted into curves of relative intensity versus wavelength. Then a curve, or an average of curves, from well above the ozonesphere is taken as representing the solar intensity incident upon the upper atmosphere. This gives $I_0(\lambda)$ in equation (1). For a specified height h within the ozonosphere, $I(\lambda)$ is given by the corresponding intensity curve. Finally the quantities $a(\lambda)$ are known from laboratory measurements, leaving $x(h)$ as the only unknown. Solving

$$x(h) = (\ln I_0 - \ln I)/a(\lambda).$$

The same value of $x(h)$ must be obtained for all values of λ, a fact which can be used to advantage in obtaining accurate results. The process of determining $x(h)$ is illustrated graphically in Fig. 2, for a spectrum corresponding to 30 kilometers, and for one corresponding to 2 kilometers.[2] As indicated in the picture, a correction for Rayleigh scattering must be made at the lower altitudes, where the air molecules scatter energy out of the sunlight beam, causing an attenuation of the sunlight intensity in addition to the attenuation due to ozone.

Since $x(h)$ represents the total amount of ozone between the recording spectrograph and the sun, it is the amount of ozone vertically above the instrument only if the sun lies directly overhead. In other cases $x(h)$ is the total ozone along a path inclined to the vertical at an angle equal to the

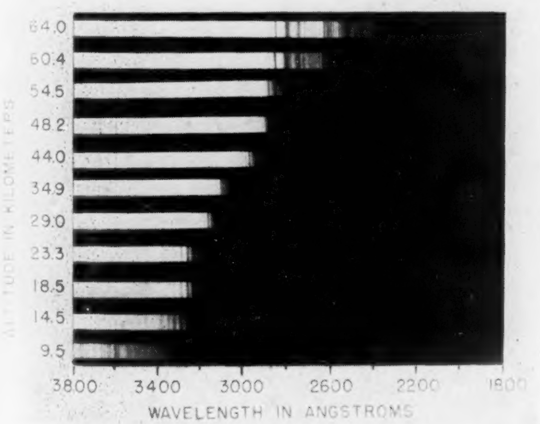

FIG. 1. Series of solar spectrograms obtained with NRL slit type spectograph on June 14, 1949.[1]

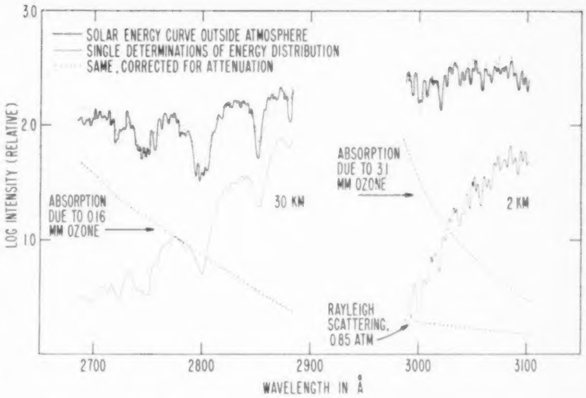

FIG. 2. Relative solar intensity distribution curves above and below the ozonosphere.[2]

zenith angle of the sun, and is what one might refer to as total slant ozone. A geometric conversion must be applied to it to give the total amount of ozone vertically above the point of observation. If desired, further conversions can be applied to give a curve of local concentration versus altitude. Results obtained by Tousey and colleagues on several rocket flights at White Sands, New Mexico, are shown in Fig. 3.[1, 2] Note that the curve for June 14 extends to 70 kilometers, well beyond the levels attainable in balloons.

Atmospheric Density at High Altitude

At one time it was thought that the atmosphere was isothermal and quiet above the troposphere. With this assumption it was relatively simple to calculate the variation of pressure and density with height. Today, however, it is known that the upper atmosphere is neither of constant temperature nor quiet. Heating, dissociation, ionization, and winds are caused by absorption of energy from sunlight. Solar and lunar tides, and impinging particle radiations also have their effect. The upper atmosphere, in fact, turns out to be far from simple, and much theoretical work has been done in an effort to understand it. For lack of accurate experimental data, however, important questions remain unanswered.

For many of the theoretical studies an important parameter is the air density to be encountered in the high atmosphere. Upon the values taken for this parameter depend the calculated heights at which different radiations are absorbed. Prior to the appearance of the rocket, the assumed density values were gleaned from various indirect bits of evidence, and were not always correct. In the levels above 200 kilometers, corresponding to the F-region of the ionosphere some of the assumed values now appear to have been much too high.

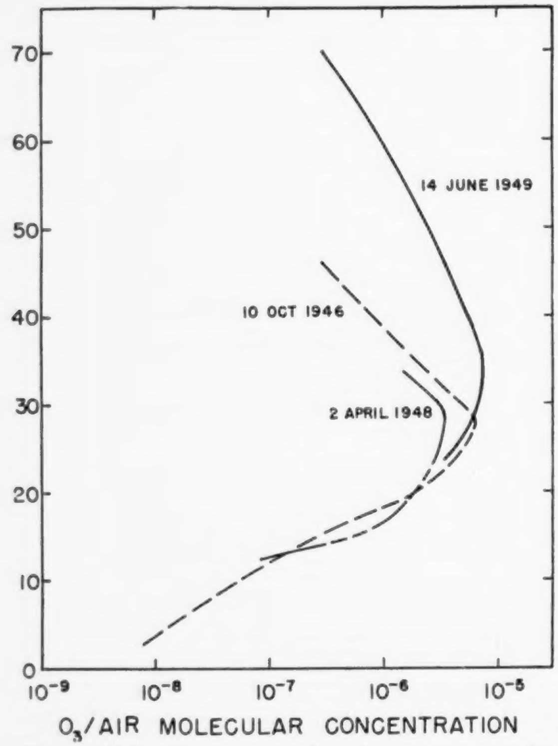

FIG. 3. Molecular concentration of ozone versus height above White Sands, N. M. (Based on data of Johnson *et al.*[1, 2])

Havens and colleagues have made direct rocket determinations of atmospheric pressures, densities, and temperatures above White Sands, New Mexico.[3, 4] Some of their results are presented in the drawing of Fig. 4. Up to about 100 kilometers, where one finds the E-region of the ionosphere, both density and pressure fall off roughly by a factor of 10 for every 10 miles increase in altitude. If the one is expressed in grams per cubic meter and the other in millimeters of mercury, then they both have approximately the same numerical value throughout this altitude range. Beyond the E-region, both pressure and density decrease more slowly with height than at the lower levels, and the temperature probably increases much as is shown. The temperature curve shown, however, was derived from pressure and density measures on the basis of an assumed composition for the upper atmosphere, and must remain speculative until the atmospheric composition has actually been determined by measurement.

Of particular interest is the density measure at 219 kilometers obtained during the flight of a Viking rocket on August 7, 1951.[4] The value was found to be within 20 per cent of 10^{-7} gram per cubic meter, which is one or two orders of magnitude lower than many had expected. This measure must now be taken into account in further theoretical work, although it represents but a single observation. Additional measurements are, of course, highly desirable, and will be made in further rocket flights.

Ion Densities in the Ionosphere

Ever since its discovery in 1925, by Appleton and Barnett in England, and by Breit and Tuve in the United States, the ionosphere has been the object of intensive theoretical and experimental investigation. On the experimental side, the radio pulse method of Breit and Tuve has been used to accumulate masses of data on the reflection of different frequency signals from the various ionospheric levels. To shift from such data, however, to a curve of ionization intensity versus altitude requires various theoretical assumptions which cannot be tested directly. In particular the region of ionization immediately above a maximum is shielded from experimental observation from the ground. The rocket provides a means of overcoming some of these difficulties.

Suppose that a signal of frequency f is transmitted from a rocket moving at a speed v away

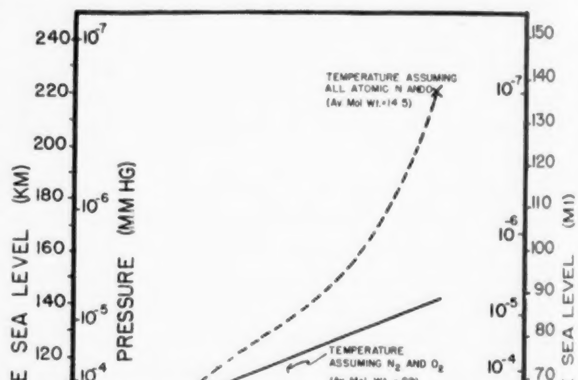

FIG. 4. Atmospheric temperatures above White Sands, N. M. Calculated from various pressure and density data published by Havens and co-workers. Solid curve based on sea-level composition. Dashed curved speculative, assuming a linear transition of oxygen and nitrogen from all molecular at 80 km to all atomic at and above 200 km.

from an observer. By virtue of the well-known Doppler principle, the observer receives a signal of lower frequency $f - \Delta f$, where

$$\Delta f = fnv/c, \tag{2}$$

where c is the speed of light in a vacuum, and n is the index of refraction, for the frequency f, of the medium in the immediate neighborhood of the rocket. J. C. Seddon used this relationship as the basis of a series of experiments to determine charge densities in the ionosphere.[5]

Two signals, one of frequency f, the other of frequency $6f$, were transmitted from a flying rocket to a ground station vertically below. At the ground station the received signals were of frequencies

$$f(1 - n(f)\ v/c)$$

and

$$6f(1 - n(6f)\ v/c)$$

The lower frequency signal was multiplied by 6 and heterodyned with the other, resulting in an output signal of frequency F where

$$F = \frac{6fv}{c}\ (n(6f) - n(f)) \tag{3}$$

F was measured from records taken in the ground station, v was determined from tracking data, and both were correlated with rocket altitude. The frequency f was fixed in setting up the experiment, and was so chosen that the sixfold frequency signal was little affected by the ionosphere, permitting one to set $n(6f)$ equal to unity. Since c is a known constant, this left $n(f)$ as the only unknown in equation (3), which one could then evaluate as a function of altitude.

Assuming that the charge density in the ionosphere is due solely to electrons, ignoring the existence of the earth's magnetic field and neglecting the effect of collisions between the electrons and air particles, $n(f)$ is given by the expression,

$$n(f) = \sqrt{1 - \frac{Ne^2}{\pi m f^2}} \tag{4}$$

in which e and m are the electronic charge and mass respectively, and N is the number of electrons per unit volume. Having determined $n(f)$ as a function of height, one can solve equation (4) immediately for N as a function of height, giving what may be termed an effective electron density.

The true state of affairs is much more complicated than is indicated in the above description. For one thing, the earth's magnetic field causes the transmitted signal to split into two rays. Also to those rays proceeding directly from the rocket to the ground station must be added additional rays which, starting upward from the missile, are reflected from overlying layers of the ionosphere. This means that the signal recorded in the ground

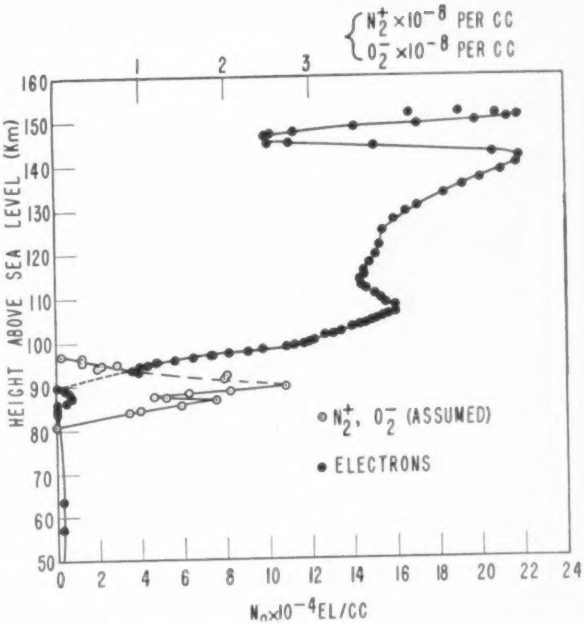

FIG. 5. Electron and ion concentrations in the ionosphere above White Sands at mid-morning, in autumn. The measurements were made during the flight of the V-2 launched at White Sands at 0958 Mountain Standard Time, September 29, 1949.[6]

station is quite complex. Its analysis is often very difficult. Also, Seddon used a more complete formula for n which takes into account the parameters neglected in equation (4). Nevertheless, in spite of the many complications, he could with care and patience sift the desired results out of the data. Curves obtained from the flight of a V-2 on September 29, 1949, at 1000 Mountain Standard Time, are shown in Fig. 5.[5] Note the ion bank observed in the neighborhood of 90 kilometers and the presence of both E_1= and E_2=layers, at 105 and 137 kilometers respectively.

Using the same basic theory, but a different experimental approach, Berning of the Aberdeen Proving Ground also has obtained curves of charge density in the ionosphere.[6] The most interesting is that derived from the flight of the famous Bumper-WAC on February 24, 1949, at 1522 Mountain Standard Time, in which a WAC Corporal launched from the nose of a flying V-2 reached an altitude of 389 kilometers. Berning's charge density curve is shown in Fig. 6.

Solar X-Rays

The various ionospheric layers are formed largely by the action of solar radiation, which being absorbed at high altitude gives rise to various photochemical processes. Some time ago, Hulburt suggested that soft x-rays cause the E-layer ioniza-

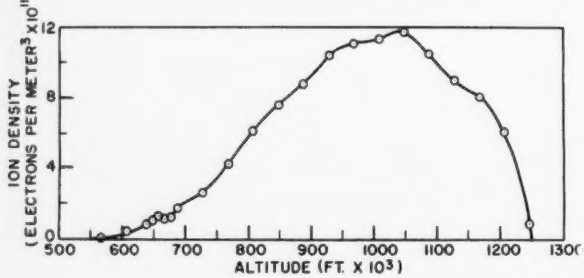

FIG. 6. Ion density in the F-region at mid-afternoon. The measurements were made during the flight of the Bumper-WAC launched at 1522 Mountain Standard Time on February 24, 1949, at White Sands, N. M.[6]

tion. Before the advent of the high altitude rocket, however, this hypothesis could not be verified by direct observation.

On August 5, 1948, Burnight discovered the presence of soft x-rays in the upper atmosphere.[7] The rays were detected with Schumann plates covered with beryllium filters. Since that time the x-rays have been studied further in various experiments with photosensitive materials and with photon counters.[8, 9] The photon counter data are particularly interesting in that they show clearly that the level of maximum absorption of the rays is in the E-region. This can be seen from the picture of Fig. 7 which was drawn from data obtained by Friedman and colleagues.[8] Estimates of the intensity in the band of wavelengths observed, i.e., from 5 to 10 A, indicate that in the totality of solar wavelengths below 100 A there might well be enough energy to account for the E-layer ionization. This, however, remains speculative until the whole range from 5 to 100 A has been covered by actual observation.

Current Sheets in the Ionosphere

As is well known, at large distances from the earth, the earth's magnetic field is essentially that of a magnetic dipole. In the neighborhood of the earth, however, there is an additional irregular field superimposed upon the dipole field. Part of the irregular field, and less than one per cent of the total field, has its origin external to the earth. Finally, a portion of the field originating externally to the earth can be represented as that produced by a current system. It has been assumed that the current systems exist in the upper atmosphere, and there have been several theories put forth as to their origin. At present, the theory most widely accepted is the dynamo theory of Balfour Stewart.[10] According to the dynamo theory the current systems arise in the E-region of the ionosphere as a result of tidal and thermal motions of the atmosphere.

Whatever their supposed origin, it is of interest to learn from direct observation whether or not such current systems actually do exist in the ionosphere. To find the answer to this question, Singer, Maple, and Bowen sent magnetometers aloft in two Aerobees fired from the geomagnetic equator in the Pacific Ocean.[11, 12] The one Aerobee, fired at 1720, 90th meridian time on March 17, 1949, was launched at a time when the daily variation in the surface field was near a minimum, presumably indicating the absence of any current sheets in the upper atmosphere. The second was launched at 1120, 90th meridian time on March 22, 1949, at a time when the daily variation in the earth's surface field was near a maximum, indicating the presence of a current sheet.

The record of the magnetometer on the first flight is shown in Fig. 8. There is a uniform fall off of field with altitude, with no sharp breaks, no evidence of the rocket's penetrating a current sheet. The record for the second flight, however, is different. As can be seen from Fig. 9, at 93 kilometers there is a sharp break in the slope of the curve, showing that the rocket had actually entered a current sheet.

High Altitude Winds

Rapid winds have long been known to exist in the upper atmosphere below 100 kilometers. They can be seen to distort long enduring meteor trains into zigzag shapes.[13, 14] Their velocities can be estimated from observed motions of the different portions of such meteor trains. Speeds in excess of 100 kilometers per hour are common. More recently, Ference and co-workers have used Aerobee rockets and sound grenade techniques to measure such winds.[15]

In the F-region of the ionosphere, however, the

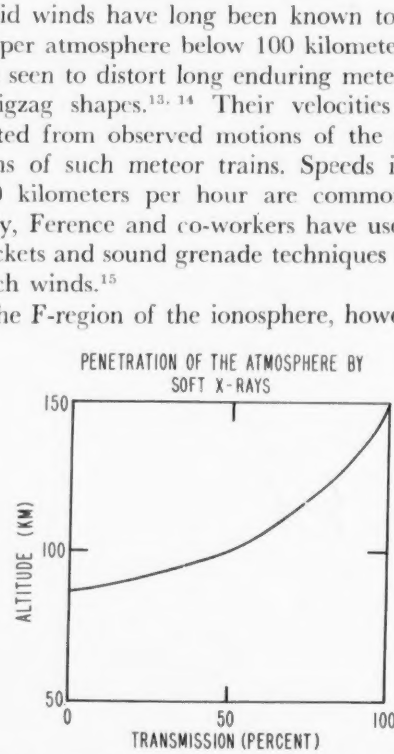

FIG. 7. Penetration of the atmosphere by soft x-rays, presumably from the sun. The curve was obtained from the averaged data of two photon counters flown in a sounding rocket.[8]

existence of actual winds was first established by direct observation during the flight of Viking 7. Prior to this, such evidence as did exist for F-region winds was indirect and not certain. In Viking 7, however, it was observed with pressure gages mounted in the rocket, that the relative wind blowing past the rocket was displaced from the direction of rocket motion. This shift was due to atmospheric winds. Assuming the wind to be horizontal, Havens and Spitz calculated that at 200 kilometers altitude the velocity was 80 ± 20 meters per second from the southeast.[16]

Cosmic Rays

Most of current high altitude cosmic ray work is being done in balloons. There is one important problem, however, which seems to require the use of rockets. This is the study of the low energy end of the primary cosmic ray spectrum. The cosmic rays consist of charged particles, mostly protons and alpha particles with some heavier nuclei. Being charged, the particles are deflected by the earth's magnetic field as they approach from interplanetary space. At a given magnetic latitude, only those particles of sufficient magnetic rigidity can reach the top of the atmosphere; all others are deflected away. The minimum magnetic rigidity for penetration to the top of the atmosphere increases from zero at the geomagnetic poles to roughly 60 billion volts at the geomagnetic equator.

If the primary radiation contained appreciable numbers of particles of all rigidities, then the total intensity would increase steadily as one moved away from the equator toward the poles. At the surface of the earth this actually happens, until one reaches about 40° geomagnetic latitude, but at higher latitudes the intensity remains constant.

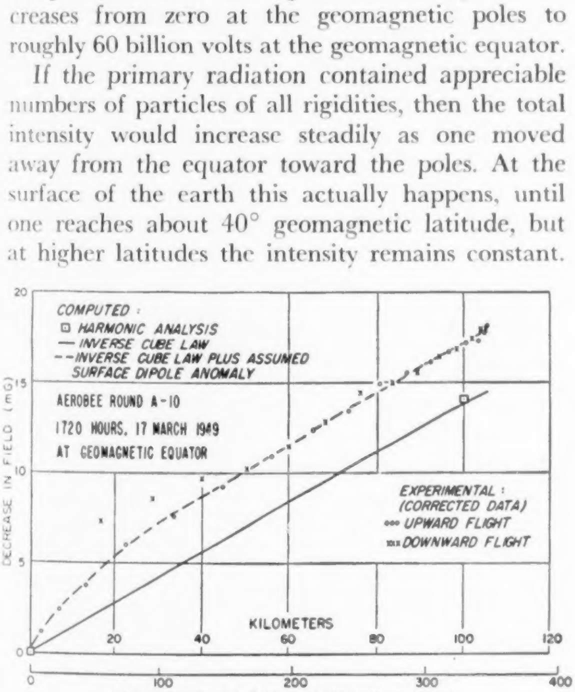

FIG. 8. Earth's magnetic field versus height above the geomagnetic equator, at 1720 local time on March 17, 1949. This was near the time of minimum variation in sea level field.[12]

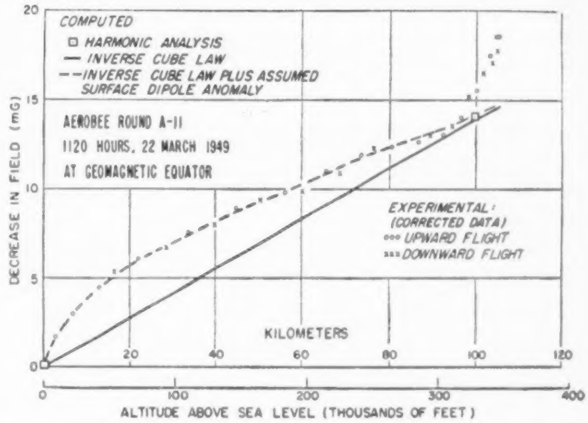

FIG. 9. Earth's magnetic field versus height above the geomagnetic equator at 1120 local time on March 22, 1949. This was near the time of maximum variation in sea level field.[12]

This cutoff could be due to the absence of lower rigidity particles in the primary radiation. On the other hand, some of it could also be due to absorption by the atmosphere, and in fact, at balloon altitudes the cutoff latitude does move northward to roughly 60°. At balloon altitudes, however, there still remains an appreciable amount of air above. Hence, it is impossible from balloon experiments to say whether the cutoff is due to the remaining atmosphere or to the actual absence of the lower energy primary rays.

Van Allen of the State University of Iowa has been attacking this problem by sending up Geiger counters in small rockets launched from balloons in the neighborhood of the geomagnetic north pole. This work is in progress now, but the first experiments reported have indicated the absence of charged primary cosmic rays of magnetic rigidity less than 1.2 billion volts.[17]

Problems Still to be Solved

Many important questions concerning the upper atmosphere remain unanswered. For some of them the rocket seems at present to be the best, or even the only, means for obtaining definitive answers.

It is desirable to obtain the spectrum of the sun in the short wavelength region not yet observed in detail. Since the wavelengths concerned are cut off before reaching the ground, or even balloon altitudes, it will be necessary to send recording equipment aloft in rockets into and above the absorbing layers. Some of the radiations are involved in the formation of the F-regions of the ionosphere, and for their study the rockets will have to rise to several hundred kilometers.

The chemical and physical makeup of the high atmosphere is fundamental to an understanding

of what goes on there. Measurements should be made to determine the composition of the air and its state of ionization, dissociation, and excitation. The matter of diffusive separation in the high atmosphere is yet to be settled. To carry such studies into the F-region of the ionosphere again will require rockets that can rise to several hundred kilometers.

The various particles which impinge upon the upper atmosphere should be studied at first hand. As many of them are stopped at high altitude, this will involve sending equipment up in rockets. Among those particles which are of interest are those involved in auroral activity, the low energy end of the primary cosmic ray spectrum, and micrometeorites.

The molecules of air in the high atmosphere continually emit what is called an airglow. This radiation is associated with the various photochemical processes going on there. Up to the present, however, there has been great disagreement as to the heights from which the different radiations come. It appears that the only way to settle the matter is to use rockets to pin down the levels at which the different wavelengths originate. Some of the estimated heights correspond to the F-region, and it may be necessary to send recording equipment to several hundred kilometer altitudes before the final answers are obtained.

Finally, upper air densities, pressures, temperatures, and winds are fundamental parameters in the study of the atmosphere, and should be measured to as high as possible, and as often as possible.

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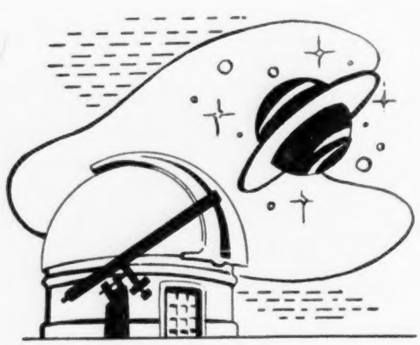


The Summer Science Camp as a Means of Attracting Talented Students to Science Careers

RUSSELL H. JOHNSEN

The author received his B.S. in chemistry from the University of Chicago in 1947. He studied organic chemistry under Professor A. L. Wilds, at the University of Wisconsin, and received his Ph.D. in 1951. Since then he has been assistant professor of organic chemistry and chairman of the Department of Physical Science for General Education at the Florida State University.

SO much has been written and said about the dependence of modern society on scientific and technological progress that there seems little necessity for restating the case. That this scientific progress depends for continuing success on an ever increasing flow of technically trained people into the schools, laboratories, and industries of the nation certainly cannot be denied. However, it has become strikingly apparent in the past few years that the actual number of people preparing for professional careers in science and engineering falls far short of the current demand. The situation is even more alarming when reasonable estimates of future demands are studied. While, in general, college enrollments have been on the increase, the percentage of those embarking on scientific careers has actually diminished.

That this trend has developed in the face of publicity the scope of which has never been equaled, and further, at a time when everyone recognizes that this is a "scientific age" should and has been cause for considerable concern. It is quite evident that publicizing the achievements of science, or utilizing the products of science, is of small significance in persuading young people to make one of the sciences or engineering fields their life's work.

The reasons for this reluctant attitude have never been fully explored. It may in part be due to a real lack of understanding of the nature of science which takes the form of an abhorrence of participating in that branch of human activity that has produced alphabet bombs, bacteriological warfare, and guided missiles, or it may be due to a lack of willingness to embark upon a career in which the rewards are often somewhat intangible. Whatever the reasons may be, there is no doubt that every effort must be made to dissuade the young person about to make a career choice from overlooking the possibilities in the science fields.

Publicity, visitation to high schools, the dissemination of printed material, and the usual type of "Career Day" activity is evidently not proving wholly effective in seeking out those people with an interest in science and with the necessary talents. A more forceful and effective means for accomplishing these ends was therefore sought at this university—a means that would really give students a feeling for the nature of scientific work, dispel their illusions, and point out the unlimited satisfaction that so many have found in such careers.

Such a need seemed to be met in a suggestion made by Mode L. Stone, acting dean of the School of Education, for a Science Camp, a student participation program for selected high school juniors and seniors of the state, a camp extending over a period of several weeks and giving individuals the opportunity to achieve first-hand experiences in most of the fields of scientific endeavor. It is to be emphasized that the aim of this program was not to acquaint students with the nature of college life, as so many similar sounding activities do.

It was felt that intimate contact with the scientific activities in progress at Florida State University through a planned program could do much toward stimulating or crystallizing the interest of young people about to make career choices. Further, it was anticipated that the program could do much in assisting the participants to make a more valid choice among the various fields of science, since it is certainly true that many students of high school age are quite unfamiliar with some of the the less publicized fields.

Our experience with the first camp, held on the university campus June 15 to 26, leads us to be-

lieve that to a large measure the projected goals were realized and that activities of this nature could profitably be undertaken on a widespread scale as one measure to assure a continuing supply of scientifically trained persons.

The science camp was sponsored by and developed through the cooperation of the College of Arts and Sciences and the School of Education. Since this University operates on a twelve-month basis, the personnel involved in the program were regular members of the teaching staff.

The staff was chosen with considerable care so that every one selected was highly interested in his field, an active researcher, and able to convey that special enthusiasm that is vital to a successful scientific career. The student participants were chosen with equal care. Every high school in the state was canvassed for possible applicants by means of a printed brochure, form letters to science teachers and principals, and frequently by personal letters to these individuals. Applicants were first screened by local science teachers and then by the science camp staff by means of questionnaires, letters of application, and letters of recommendation.

The students' stay at the University was financed by the individual, and expenses were therefore kept to the barest minimum. Housing was furnished by the University for the entire period for a fee of eleven dollars; food was purchased on an individual basis. A fee of five dollars was assessed each student to cover the cost of transportation for the field trips, food on the trips, and miscellaneous items. It was the consensus of the students that the cost of the Camp was not excessive, and should not prove a deterrent to future participants. A small number of students unable to meet these modest expenses were subsidized by civic organizations in their home towns or by activity funds of the high schools.

The guiding principle under which the Science Camp was organized was student participation. It seemed likely that the most intense and lasting intellectual stimulation would come from doing, rather than from second-hand reports on the activities of those in scientific work. To this end, lecturing was held to an absolute minimum and any lectures were of the demonstration type, to make them as vivid as possible. The emphasis, then, of the entire period was placed on laboratory work, field trips, and informal work and observation in the research laboratories of the departments participating in the program. Each department participating prepared a program individually but within the stated aims of the Camp. These programs were submitted to a steering committee in advance, and every effort was made to integrate, avoid duplication, and produce as stimulating a program as possible. A brief résumé of each departmental program indicates the kind of activity that was found to be quite effective in this type of operation.

Bacteriology. One two-hour laboratory: (1) photogenic and fluorescent bacteria; (2) cultural characteristics; (3) some aspects of diagnostic bacteriology; (4) demonstration of various instruments.

Botany. One two-hour laboratory: (1) demonstrations of oddities in the plant kingdom; (2) microscopic examination of pond water, hair, various algae and fungi (students made own mounts); (3) films, "Plant Growth" and "Genetics."

Chemistry. Two demonstration lectures: "Light and Chemistry" and "Chemical Phenomena." One two-hour laboratory period during which the following experiments were performed: (1) preparation and use of light-sensitive paper, the gum-bichromate process; (2) copper hydroxide stalactites; (3) acid-base indicator from red cabbage leaves; (4) glass blowing.

Geology. One illustrated lecture: "The Changing Features of the Earth." One two-hour laboratory period: identification of rocks and minerals; chemical identification of minerals.

Mathematics. One lecture demonstration in four parts: (1) "The Role of Mathematics in the Study of Science"; (2) "Celestial Navigation"; (3) "Choice and Chance"; (4) "Seismic Prospecting for Oil."

Meteorology. One lecture demonstration: "Weather forecasting and frontal theory." One two-hour laboratory: weather maps were plotted and analyzed; the taking of pilot balloon observations was demonstrated.

Physics. Three lecture demonstrations: (1) "Conservation of Momentum"; (2) "The Scale of the Solar System"; (3) "The Nature of the Cosmos." Two two-hour laboratory periods: (1) construction of crystal radio receivers; (2) construction of a simple telescope.

Physiology. One two-hour laboratory period: (1) elementary physiology demonstrations, including blood pressure, heart sounds, muscle activity records, and blood counting techniques; (2) biophysics—sounds and visual reproduction of nerve impulses; (3) cell physiology—cell respiration techniques using Warburg apparatus; (4) mammalian physiology.

Psychology. One two-hour laboratory period: (1) The work of the Psychologist; (2) child development demonstrations; (3) visit to experimental laboratories; (4) film, "Ape and the Child."

Zoology. One two-hour laboratory period: (1) a chick embryo was removed from the egg, studied microscopically for heart beat, circulation, and general structure; (2) the technique of constructing quick permanent mounts on slides using glycerin sealed with paraffin was employed; (3) the technique of blood-typing was illustrated.

In all these activities the emphasis was on illustrating the approach of a particular area and on the nature of the field rather than on the convey-

ance of subject matter. An equally important type of activity consisted of field trips of various kinds. Two all-day trips were taken. One was to the laboratories of the University's Oceanographic Institute, where the students dredged for live marine specimens, made a microscopic examination of plankton, and studied the live specimens of marine life housed at the Institute. Another facet of this trip was geological in nature, shore-line features and other available points of geological interests were studied under the direction of a staff geologist. The second major trip was divided into two parts. The first was to Wakulla Springs, a spring of great depth and clarity which allows the study of marine life in its natural habitat, and the second was to the nearby federal wild-life sanctuary. In addition to these two major trips, an inspection of the state chemists' laboratories was made. Several of the evenings were spent in star study and telescopic observations.

A considerable portion of the time was spent in visiting the various research laboratories on the campus where current work, techniques, and procedures were discussed in great detail. Many of the participants felt that this portion of Science Camp activity was of the most interest and benefit to them, for it was here that the students were best able to meet with graduate students and faculty on an informal basis and discuss the work that interested them most. This informality and intimate contact was furthered by a number of social events attended by the participants in the camp and the members of the science faculty. Private consultations on such subjects as opportunities for careers, the content of various fields, and the nature of research activities in these fields were also available and were utilized to a very considerable extent. These consultations were informal and spontaneous; a feature, it seemed to us, that made them much more effective than carefully arranged interviews.

Any objective evaluation of the worth of the Science Camp idea must of course await the final choice of career by individual participants. However, considerable effort was made to evaluate this aspect of the Camp subjectively through the immediate reactions of the students, the reactions of the staff who were responsible for operating the Camp, and the reactions and observations of a group of high school science teachers who acted as observers during the entire period of the program and who accompanied the students on all their activities. The last group was also valuable in evaluating the simple mechanics of the program.

Two hours of the final day were devoted to an oral evaluation of the camp by the students. This was conducted by members of the University faculty not participating directly in the Camp. These were chosen in order to minimize the possibility of influencing the students' responses. This evaluation was conducted by asking each of the students a series of questions designed to encourage free discussion of the Camp's activities, shortcomings, and values. A large portion of the students freely discussed all aspects of the camp. In general, they felt that much of real value, career guidance, awakening of interest in new fields, and increased understanding of the nature of activities within different science areas, was obtained. Almost all claimed a heightened interest in scientific work as a result of their experiences and felt that their remaining high school work would take on new purpose and direction. It was the consensus of the group that these objectives were best and most readily realized through intimate contact with the members of the science faculty, although it was felt that all the activities of the Camp contributed.

It is the judgment of all the members of the faculty who participated directly and of other observers that this first Science Camp has admirably served the purpose for which it was intended. It was an extremely heartening experience, in the face of the general pessimism, to find such unalloyed enthusiasm for science in this group of young people. It seems quite evident, then, that further activities along these lines can do much to help alleviate the shortage of trained people that has been the cause for much justifiable concern.

X-Ray Angiography, Handmaiden to Heart Surgery

J. GERSHON-COHEN

The author received the degree of Doctor of Medical Science from the University of Pennsylvania where he is now assistant professor of radiology in its Graduate School of Medicine, and director of the department of radiology in the Albert Einstein Medical Center, Northern Division, Philadelphia. From his researches have come more than one hundred scientific reports on subjects in physiology, biology, and clinical radiology. With his co-workers he has been the recipient of several awards for scientific reports or exhibits from the International Congress of Radiology, the American Medical Association, and the College of Physicians in Philadelphia.

BRILLIANT advances in surgery of the heart and blood vessels during the past decade have been fostered in great measure by parallel advances in the roentgenology of these structures. During this period, which might be called the era of angiography, daring technics, new instruments, and novel x-ray apparatus have been evolved. Prominent among the designers of these mechanisms have been Feitelberg and Sussman of New York, Scott of St. Louis, who adopted the use of the Fairchild A-S aerial camera, Morgan of Baltimore, Fredzell of Sweden, and Chamberlain and Hogan of Philadelphia. Serial x-ray films may be obtained of the moving intravascular opaque column with electronic thyrotron timers (1/120–1/20 sec) at intervals from 1/6 to 1/2 second with rugged apparatus, which is extremely versatile, furnishing two pairs of stereoscopic films exposed simultaneously at right angles. Sequencing devices for exposures can be preset in accordance with the different phases of the heart beat and with the anticipated time of passage of the opaque column through that portion of the heart or blood vessels under examination. Determination of this "time of passage" may be obtained by the preliminary use of fluorescent dyes, chemicals, or radioisotopes; moreover, simultaneous electrocardiograms can be made part of the completed record (Fig. 1).

It is hard to believe that all these modern x-ray technics have been evolved during the past decade, for it was only in 1924 that the Frenchmen Sicard and Forestier for the first time visualized human veins under the fluoroscope by the injection of four cubic centimeters of a forty percent emulsion of iodized poppy seed oil (lipiodol). Beberich, Hirsch, and Brooks in the same year also obtained x-ray pictures of peripheral arteries and veins filled with solutions of iodine and bromine. In 1927, the Portugese neurosurgeon Egas Moniz first visualized the intracranial arteries with a solution of strontium bromide. Following soon thereafter was the brilliant work of the other Lisbon investigators, dos Santos, Lamas, and Caldas, who in 1929 were the first to introduce opaque media directly into the aorta with a needle inserted to the left of the spinal column below the ribs. In the same year, Forssmann introduced a ureteral catheter into one of his own veins at the crook of the elbow and then maneuvered its tip directly into the right auricle. His intention was to demonstrate how therapeutic infusions could be applied directly to the interior of the heart. In 1931 he followed

FIG. 1. The Chamberlain-Hogan x-ray apparatus with two x-ray tubes and two Fairchild cameras on a circular mobile mount which can be placed in either the horizontal or vertical position for taking simultaneous stereoscopic angiographs at right angles.

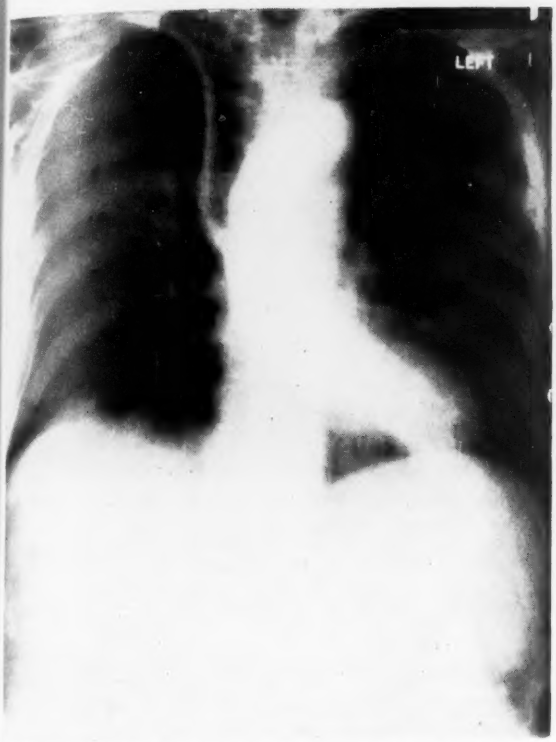


FIG. 2. Angiocardiograph of an adult showing the opaque column in the left ventricle and the aorta separated from a second column just entering the superior vena cava. The displacement between these two columns was due to a thickening of the mediastinum and not a tumor, as was originally suspected.

this with the use of contrast media for visualizing with x-ray pictures the various chambers of his heart, but did not succeed because of the low concentration of his solution. Later, Moniz, Carvalho, Lima, and Saldanha discarded the catheter and injected the opaque media directly into a vein at the bend of the elbow. They found that this made possible satisfactory visualization of the heart chambers and the blood vessels of the lungs, and finally, of the aorta itself. Nuvoli had the temerity in 1936 to insert a needle directly into the human heart in preparation for x-ray studies. It remained, however, for the Cuban pediatricians Costellanos, Pereiras, and Garcia, in 1937, to make the first major contribution to clinical angiocardiography by reporting a series of successful attempts to demonstrate congenital heart malformations in children under six years of age with the use of opaque solution injected via needle into peripheral veins.

Angiocardiography came of age in 1938 with the extensive work of the Americans Robb and Steinberg. After much experimentation with this new method, they concurred with the Cuban workers that for successful angiography (a) opaque solutions had to be nontoxic and concentrated, (b) needles had to be large, (c) venous blood had to be withdrawn into the syringe before injection so as to flush the opaque material through the arm vein, (d) the injection had to be made very rapidly, and (e) good x-ray apparatus had to be available in order to demonstrate the moving opaque column through every phase of transit in the heart chambers, pulmonary artery, and aorta.

X-ray films of the heart chambers and great vessels of the chest are now obtained with fifty percent solutions of iodine. This high concentration of iodine is necessary to overcome the diluting effect of large volumes of blood in the heart and lungs. With this procedure various congenital anomalies of the heart and great vessels can be shown. Until about fifteen years ago, children born with defects of the heart were beyond medical help and usually died at an early age. Now that surgeons have learned how to make new openings or to close defects in the septa between the heart chambers, and since their deftness has made possible joining the ends of blood vessels, blood can be shunted around areas of constriction or into the lungs or extremities when these parts may be in need of more or less blood. Although some of the surgical achievements in this field are spectacular, they could not have been possible without the tremendous advances of modern x-ray technics. Before the surgeon decides to operate, the x-ray findings help clarify the diagnosis. Moreover, the x-ray findings alert the surgeon to be ready for special technical procedures once he has entered the chest. The operation then can be done in the shortest possible time, and this is important when one remembers that temporary closure of important blood vessels often is necessary during these operations.

Simply to enumerate some of the conditions revealed by these new x-ray technics is to give some insight into the scope of angiocardiography. Such conditions are visualization of (a) obstruction to the flow of blood through the superior vena cava; (b) determination of the number, size, and shape of the heart chambers as well as the presence of any abnormal openings between them; (c) visualization of position, size, and shape of abnormal communications of the aorta to the nearby pulmonary artery; (d) visualization of aneurisms of the aorta or pulmonary artery, or arteriovenous aneurisms in the lungs (such lesions must be differentiated from lung tumors which they simulate); and (e) differentiation of tumor-like shadows in the complicated structures of the

mediastinum (Fig. 2). This is very important in planning operations for cancer of the lung, because by this method metastasis to the mediastinum can be ruled out, otherwise surgery may be of little avail.

Let us stop to review a case history demonstrating how these new procedures are brought to bear in a typical problem. A child, seven years of age, had had cyanosis since birth. He always had been a feeding problem and he had grown slowly, without the endurance of a normal child. His physician had heard a rasping murmur over an enlarged heart, and this murmur had been timed with systole. The number of red blood cells had been increased twenty-five percent above normal, a sign of impaired oxygenation of the blood confirmed by actual test of oxygen saturation of the blood in a peripheral artery. The routine fluoroscopic and x-ray studies of the chest revealed a large heart and prominent blood vessels in the lungs with misplacement of the aorta to a high anterior position above the right ventricle. These findings suggested the possibility of congenital transposition of the great vessels of the heart.

Angiocardiography revealed entrance of the injected column of opaque material into the right auricle from the superior vena cava. The head of the opaque column then properly entered the right ventricle, but instead of being propelled to the lungs via the pulmonary artery, which normally stems from the right ventricle, the whole column was diverted to the periphery of the body via the misplaced aorta. This meant that the unoxygenated carbon dioxide-laden blood, gathered into the vena cava from outlying portions of the body, was shunted back into the general circu-

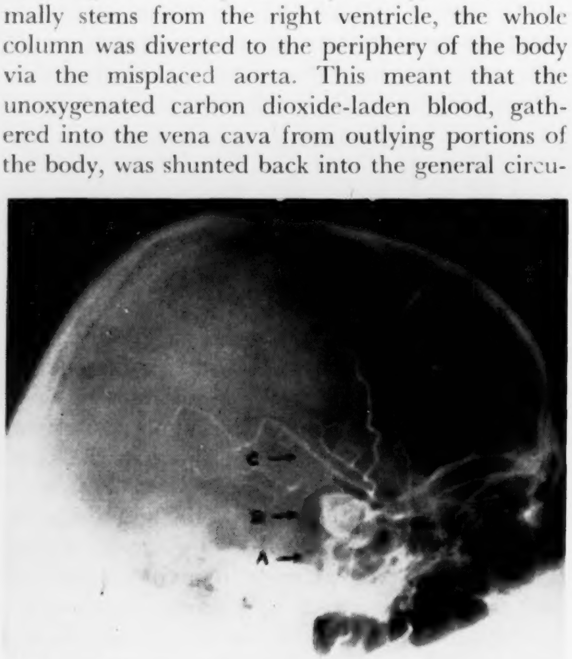


FIG. 3. An aneurism is present near the pituitary gland: (a) internal carotid artery; (b) aneurism; (c) cerebral arteries.

FIG. 4. Streaming from the opaque material injected directly into the spleen is the vein to the liver. Some varicose veins have filled around the lower esophagus (arrowed), as well as the inferior vena cava which filled rapidly because this examination was made after a portal-caval shunt in a patient with cirrhosis of the liver.

lation without first having been sent to the lungs for adequate oxygenation. Further examination of the serial x-ray films revealed leaks of the opaque material from the right to the left auricle and from the right to the left ventricle. This meant that there were abnormal openings between the heart chambers, and through these congenital defects small quantities of blood had gained access to the proper circuit through the lungs before being pumped back again into the general circulation; otherwise the child could never have survived birth.

Surgical treatment in this case consisted of anastomosing the right pulmonary artery to the superior vena cava and the proximal portion of the right subclavian artery to the distal portion of the pulmonary artery. This operation is complicated and requires great surgical skill. But after such an operation, more blood can get from the systemic venous circulation to the lungs before being distributed back to the general circulation. The child who underwent this operation made a remarkable recovery. The blueness of his lips disappeared, he gained in strength, vigor, and nutrition. Operations similar to this one have been done successfully many times. Defects in the septa between heart chambers may be closed or created; stenotic or constricted valves between the chambers may be enlarged; abnormal connections between vessels such as the aorta and the pulmonary artery can be severed; or anastomoses between arteries and veins can be made as dictated by the dynamics of an impaired circulation.

In order to demonstrate the arteries in and around the brain, one of several available thirty-five percent iodine solutions is injected into the carotid artery at the base of the neck. An expert, usually the neurosurgeon, can do this unerringly by inserting a large needle through the skin directly into the artery. Demonstration of the cerebral branches of this artery then can be obtained. The presence or absence of brain tumors is determined by the function, displacement, or distortion of blood vessels in or around such a tumor. Abnormal saccular aneurisms, often causing symptoms like those of tumors, can be accurately visualized (Fig. 3). Other conditions, such as inflammation, hemorrhage, clots, adhesions, deformities of structure, and abnormal communications between arteries and veins also can be diagnosed. To demonstrate disease in the posterior portions of the brain, the vertebral artery, deeper in the soft tissues of the neck than the carotid artery, also can be reached through a skin puncture with a long needle. Lately, C. F. Dotter and his group have inserted needles through small burr holes in the skull directly into the large venous channels on the surface of the brain. In this way, x-ray pictures of the large cerebral venous sinuses that course over the surface of the brain can be obtained.

When either congenital or acquired disease is suspected, the aorta can be explored with an opaque solution injected through a long needle inserted where the aorta branches from the heart; or the needle can be thrust into the aorta where it courses along the posterior chest wall just to the left of the spinal column. The opaque material can be directed rapidly into the flowing blood stream against the current, thus opacifying the blood column in order to reveal aneurisms, constrictions, or abnormal communications with other nearby vessels. Accurate surgical planning then becomes possible and the surgeon knows in advance whether there is an adequate collateral or compensatory circulation.

Opaque solutions injected into the aorta reach its branches to the liver, spleen, kidneys, and uterus, where the presence of certain tumors and vascular defects also can be seen. This procedure already is employed on a wide scale for the diagnosis of tumors and other diseases of the kidney. Conversely, opaque material can be injected directly into an organ such as the spleen, and the passage of the material can be followed into the collecting veins. Revealed this way is the special venous plexus to the liver. In our department, Samuel Levine has shown impairment of this circulation with the formation of internal varicose veins around the lower end of the esophagus (Fig. 4).

Similarly, deep varicose veins in the extremities may be shown by injecting the distal peripheral veins with opaque material (Fig. 5), or the arteries may be injected directly to show the adequacy of circulation in limbs threatened with gangrene or otherwise poorly furnished with arterial blood because of arteriosclerosis or some other cause.

With these modern x-ray technics, every organ of the body now can be demonstrated by vascular opacification with nontoxic materials injected rapidly as a single continuous column through a needle properly placed in position, but the x-ray specialist has had to refamiliarize himself with the anatomy and developmental vagaries of the vascular system. Not since the days of his anatomy

Fig. 5. Extensive network of superficial varicose veins secondary to an occluded deep venous circulation revealed in x-ray film after injection of opaque material into vein at ankle.

lessons as a first year medical student has he been so concerned with the blood vessels of the body. He is now an important member of the team of internist-cardiologist, physiologist, surgeon, and anesthesiologist for the accurate diagnosis and surgical treatment of what was regarded until recently as incurable congenital heart disease. This clinical advance would not have been possible without the preceding fundamental work of the experimental physiologist, surgeon, radiologist, and of the host of other research workers who have pioneered new routes to a healthy long life for patients who formerly were doomed to a short and handicapped existence.

Books Reviewed in SCIENCE

December 4

Psychosomatic Research. Roy R. Grinker. New York: Norton, 1953. 208 pp. $3.50.
Reviewed by Enoch Callaway III.

Biochemical Preparations, Vol. 2. Eric G. Ball, Ed. New York: Wiley; London: Chapman & Hall, 1952. 109 pp. $3.00.
Reviewed by Ralph C. Corley.

December 11

Exploration Hydrobiologique du Lac Tanganika, Vols. I–III. Brussels: Institut Royal des Sciences Naturelles de Belgique, 1949–53.
Expédition Océanographique Belge dans les Eaux Côitières Africaines de l'Atlantique Sud, Vols. I–IV. Brussels: Institut Royal des Sciences Naturelles de Belgique, 1951–52.
Reviewed by Joel W. Hedgpeth.

The Biology of Paramecium. Ralph Wichterman. New York–Toronto: Blakiston, 1953. 527 pp. Illus. $9.00.
Reviewed by T. M. Sonneborn.

Low Temperature Physics: Four Lectures. F. E. Simon *et al.* New York: Academic Press; London: Pergamon Press, 1952. 132 pp. Illus. $3.50.
Reviewed by J. G. Daunt.

December 18

An Introduction to Anthropology. Ralph L. Beals and Harry Hoijer, with collab. of Virginia M. Roediger. New York: Macmillan, 1953. 658 pp. Illus. $6.00.
Reviewed by David B. Stout.

The Chemistry of Synthetic Dyes, Vols. I and II. K. Venkataraman. New York: Academic Press, 1952. 1442 pp. Illus. $29.00 for set of 2 vols.
Reviewed by Wallace R. Brode.

X-Ray Crystallographic Technology. André Guinier; trans. by T. L. Tippell; Kathleen Lonsdale, Ed. London: Hilger and Watts, 1952. (U.S. distrib.: Jarrell-Ash, Boston.) 330 pp. Illus. + plates. $9.50.
Reviewed by J. D. H. Donnay.

Electrochemical Data. B. E. Conway. Amsterdam-Houston: Elsevier, 1952. 374 pp. $8.75.
Reviewed by Henry B. Linford.

December 25

Histochemistry: Theoretical and Applied. A. G. Everson Pearse. Boston: Little, Brown; London: Churchill, 1953. 530 pp. Illus. + plates. $12.00.
Reviewed by Isidore Gersh.

Measurement Techniques in Mechanical Engineering. R. J. Sweeney. New York: Wiley; London: Chapman & Hall, 1953. 309 pp. Illus. $5.50.
Reviewed by H. L. Mason.

Toxicity of Industrial Organic Solvents. Rev. ed. Medical Research Council, Industrial Health Research Board, Report No. 80. (Revised in consultation with the Toxicology Committee.) Ethel Browning. London: H.M. Stationery Office, 1953. 411 pp. £1.
Reviewed by Earl T. McBee.

BOOK REVIEWS

Galileo Galilei. Dialogue on the Great World Systems. In the translation of T. Salusbury. Revised and annotated by Giorgio de Santillana. Chicago: University of Chicago Press, 1953. lviii + 506 pp. Illus. $12.50.

ALL students of science will welcome Giorgio de Santillana's excellent translation of Galileo's *Dialogue on the Great World Systems.* An available English edition of this great work has been long overdue. The Salusbury edition of 1661 was not only rare, but also unreliable and obscure. De Santillana, however, has wisely selected that translation in Jacobean prose as the basis of his own, to do justice to the rhythm of the baroque original. Certainly modern scientific language would be inappropriate to interpret a historical period during which precise technical terms were nascent.

The importance of this *Dialogue,* historically, is that it stimulated the final investigation of Galileo by the Inquisition and served as primary evidence in his subsequent trial. Galileo is represented as having "gambled everything, not on deceiving, but rather on persuading the leaders of the church." The author claims that Galileo "deserves heeding no less than Aquinas himself." Psychologically, the book is significant in its revelation of Galileo's mind—in comparison with his later perjury.

The *Dialogue* itself is carried on by three individuals. Filipo Salviati, who had studied with Galileo at Padua and lived in Florence, speaks for the author. Sagredo is a typical man of the Renaissance world. Simplicio is a typical Aristotelian professor, obstinate and literal-minded. The main topic of their conversation is the justification of the revolutionary Copernican system of the world as compared with the traditional Ptolemaic one. The Platonic (Socratic) conversation extended over four days, and deals with the following primary topics: (1) the universe is a whole and perfect; (2) the authority of classics used against experimental evidence; (3) is there a time of quiescence between contrary motions? and (4) the problem of tides. The last mentioned is sometimes called "Galileo's folly," inasmuch as he incorrectly attempted to argue that the tides are a direct physical proof of the earth's rotation. The reader will find W. D. Stohlman's appendix, An Astronomical Note on the Two Systems, very helpful in understanding the text. It emphasizes the Ptolemaic system inasmuch as, strictly speaking, this is only a technical modification of the Copernican one.

One of the outstanding merits of de Santillana's edition is its annotations. They are invaluable as being the personal judgments of a scholar who has had both extensive and intensive experiences. For this very reason, however, one wonders just how historical the so-called Historical Introduction is. The following quotations illustrate the intimate understanding of Galileo assumed by the author.

Galileo is reported as being "weary of the universities," as "playing his Pythagorean hunch." "Feared were the professors." "Made Galileo himself recoil from its formulation." "He would not have turned to mechanics if he had not thought this the weakest point of the reigning philosophy of nature and if he had not thought a change of concepts on that level would alter the whole of cosmology." "Before Galileo could come forward with such a disturbing philosophy, he knew he needed an organized physics to support his contentions." "He had come thus to the new idea of 'laws of nature,' based on mathematics." "He now knew this was the end of the whole scientific movement in Italy."

The author's remarks, always interesting, do not lack a touch of dogmatism. Thus we read that "it is safe to say we shall never know anything about the universe as a whole." "In true Christian doctrine, the creation is and remains a mystery; nor will the Christian define true knowledge as other than the supernatural experience of the soul."

In his notes on the text, the author's use of the unfamiliar phrase "circular inertia" is confusing. Even more so are his irrelevant attempts to explain Galileo's concept in this instance. Thus one reads "circular orbits become so many energy levels like those of the modern atom, which cannot come into being except through different configurations of energy imposed by some unknown will. The continuity of classical dynamics not yet being open to Galileo, he has to imagine a kind of planetary quantum theory. . . ." It would seem that one is dealing here with so-called uniform circular motion in which the central force does no work. Other remarks also appear to be anachronisms, or even false interpretations of Galileo's hazy notions. "Galileo's Archimedean dynamics," "Galileo's principle of relativity as extended to circular motions," "Galileo has the principle of conservation of momentum exactly in mind. It is only a short way to $F = ma$, but that will come only in the last years."

The index itself is fascinating in the breadth of topics covered both by Galileo and by de Santillana. Thus one is enticed to look into the text for discussion of truth and beauty, of poetry, of the humanities, of divine intuition, of Heaven, of exactitude in Nature, of scarcity and plenty, of the center of universe, of sculptors and sculptures, of the number three, of a hierarchy of explanations, of a magic circle of cosmos, of the motion of animals, of the flying eagle, of the invention of music, of the Christian doctrine of creation, of the shooting of birds, of bad faith, of the Holy Scriptures, Then too, one is induced to look up the notes of the translator referring to Aquinas, Ariosto, F. Bacon, R. Bacon, T. Browne, Calvin, Descartes, Gilbert, Kant, Locke, Montaigne, Origen, Pascal, Pindar, Pliny, Richelieu, Spinoza, and others.

RAYMOND J. SEEGER

National Science Foundation
Washington, D. C.

Galileo Galilei: Dialogue Concerning the Two Chief World Systems—Ptolemaic & Copernican. Trans. by Stillman Drake; foreword by Albert Einstein. Berkeley and Los Angeles: University of California Press, 1953. xxvii + 496 pp. $10.00.

GALILEO'S *Dialogue Concerning the Two Chief World Systems* is one of the permanent classics in the history of science. Within thirty years of its publication in 1632, it was translated into English by Thomas Salusbury. Excellent recent editions of the work are available in Italian and in German.

It is somewhat remarkable that after a lapse of three hundred years, there should appear simultaneously two English issues of the work. The two versions are complementary to each other and set a rich dish before the historians of science. The University of California edition is a completely new translation; the University of Chicago edition is a reprinting of the corrected Salusbury translation.

The University of California Press contribution is a new translation by Stillman Drake, made directly from the Italian National Edition prepared under the direction of Professor Antonio Favaro. All the handwritten additions made by Galileo after publication for inclusion in future editions and presented as footnotes by Favaro, have been inserted in full in the text by Drake. One of these at least is of great interest as it throws light upon Galileo's knowledge of the rate of acceleration in free fall (pp. 30–31). The text of the *Dialogue* proper is entirely unabridged and has been made remarkably readable in translation. Galileo's numerous flashes of humor and sarcasm have been capably preserved, and a conversational reading has been made possible by relegating all notes to an appendix. The marginal notes appear as in the original edition.

Galileo's mastery of the Platonic dialogue form was such that even in translation an illusion is created of being present in Sagredo's palace, watching the experiments that Salviati devises to illustrate his points, or sympathizing with the benign Simplicio as he stumbles into the traps prepared for him.

The illuminating foreword by Professor Einstein is of great interest to students of Einstein as well as of Galileo. Besides relating Galileo to his predecessors and to modern science, Einstein discourses on the exaggerated status usually given to individual men in the progress of science, and to the unreal dichotomy between so-called empirical and rational methods in science. It is interesting that both the original German text of the preface and its authorized translation are presented vis-a-vis. This in itself is a commentary upon the difficult problem regarding the best method in which translated works can be presented. Obviously, the examination of the original Italian writing of Galileo can have no substitute for the scholar, but necessitates a knowledge of Italian. Is it then best to reprint a translation made some three hundred years ago, or to attempt to place it into the language of today? It is a question of whether to adjust the lens to the object, or to move the object so that it is in focus with the lens.

The very spirit of Galileo is the rejection of dogma and authority. His passionate belief that science is the understandable property of all men and not of scholars alone motivated him to write his *Dialogue* in Italian rather than in Latin. For this reason, it seems preferable to attempt to retain the flavor of the original by setting it in a modern and even colloquial style of the twentieth century, as Drake has done, instead of attempting the more difficult task of projecting the reader back to the style of the seventeenth century.

In the California version, the preface and the notes have been reduced to a minimum, presumably in an attempt to encroach as little as possible upon Galileo's own words. The Chicago issue, on the other hand, includes a thorough historical introduction by Professor Giorgio de Santillana, and an extensive astronomical essay by W. D. Stahlman, as well as numerous explanatory footnotes. Apparently, Drake was concerned primarily with rendering the complete and exact text of Galileo, whereas Professor Santillana was more interested in the history of science and Galileo's relation to it.

The choice between the two versions would involve many different personal preferences. My own choice would favor the California publication because it is more complete and easier to follow for one not intimately acquainted either with astronomy or with literary styles of the seventeenth century.

Physically, the California volume is handsomely designed and beautifully printed, thus making it a contribution of which the University of California Press may well be proud.

MICHAEL B. SHIMKIN
Laboratory of Experimental Oncology
San Francisco, California

Fundamentals of Biology. W. J. Harbaugh and A. L. Goodrich, Eds. Blakiston, New York. 1953. x + 611 pp. Illus. $6.00.

SIX biologists at Kansas State College, spurred by a faculty committee's directive to "integrate subject matter in the biological sciences in such a manner that man's place in the living world may be appreciated," have collaborated to produce this elementary textbook, which perhaps both gains and loses from the circumstances of its origin. Present is a plan to emphasize basic principles, the unity of life, the functional activities of organisms, and the place of man in the world of life. Absent is the systematic orderliness of the canonical botany plus zoology course, as well as those sparks of interesting writing such as occur in existing textbooks of general biology by, for example, Woodruff, Moment, Pauli, or Hardin.

The book opens with three orienting chapters, with special attention to general ecological relationships and to the gist and bases of classification. Then follow seventeen chapters dealing with growth, food synthesis by plants, digestion, distribution, respiration, excretion, motion, coordination, reproduction, and so on through heredity, evolution, environmental relations, parasitism, disease, and conservation. The most unusual feature of the book

is that in the majority of chapters the central topic is discussed first in relation to plants, then in relation to animals at large and to man in particular. It is possible to regard this method, on the one hand, as logically and therefore pedagogically sound or, on the other hand, as a vestige of the attitude that "plants are important too."

The deliberate method of the book, in any event, frequently results in strange and possibly disharmonious bedfellows. Consider, for example, the chapter on "Growth and Differentiation in Plants and Animals," where in the course of fifty-five pages the reader runs the gauntlet from cell division, mitosis, plant nutrients, auxins, bud growth, stem growth and differentiation, leaves, root growth and differentiation, pruning and grafting, straight through theories of preformation and epigenesis, types of animal eggs and their cleavage, gastrulation, mesoderm and coelom formation, types of animal tissue cells, embryonic induction, embryonic membranes, the regeneration of limbs, and aging. And herein occur, set in boldface type and presumably new and important to the student, no less than one hundred and forty-five technical terms. It does appear that the wealth of descriptive matter in such a chapter, logically united though it is by the fact that growth and differentiation are phenomena common to most living things, may constitute for the novice a kind of scientific Procrustean bed.

Very special problems, peculiar to the wide-ranging nature of biology and augmented by its multifold relationships with other sciences, beset the attempt to synthesize knowledge in this area and to unmake the historic dichotomy between plant and animal sciences. The jockeying for position and the struggle for parity on all fronts by partisans of botany and of zoology has contributed largely to the cultural doom of each. The present book is a brave effort in the direction of synthesis, molded though it is and conditioned in its success as it is by a particular plan and by local academic circumstances. We can at least regard it as an evolutionary experiment, and hope for future books which will more clearly justify the authors' view that "it is only within the last century that biology has attained a status comparable with such sciences as mathematics, chemistry, physics, geology, and astronomy."

EDWARD S. CASTLE

The Biological Laboratories
Harvard University

Franz Boas; the Science of Man in the Making. Melville J. Herskovits. New York: Scribner's, 1953. 131 pp. $2.50.

IN this sketch of his revered master's personality and achievement Professor Herskovits has succeeded in conveying a sense of Boas' remarkable versatility, intellectual power, moral courage, and public spirit, as well as of his unique service in the development of American anthropology as both organizer and teacher. Some current misconceptions are corrected, e.g., the preposterous notion that Boas was a worshipper of facts for their own sake (p. 39, 55f.) and the equally absurd idea that he looked with scorn upon his predecessors (p. 49). Herskovits deserves special credit for showing that in ethnology Boas was not the misplaced natural scientist he has sometimes been pictured, but that part of his greatness lay precisely in adopting the methods of humanistic research where these were called for (pp. 77, 86 et seq., 93). Regrettably, the author leaves uncorrected the erroneous popular impression that Boas was an equalitarian in respect to racial endowments. It is true that he rejected the superficial contentions of racialists, inside and outside the scientific fold and was always ready to fight social injustice. But he also rejected explicitly and "with some emphasis" the no less dogmatic assertion that "there are no differences in the mental make-up of the Negro race taken as a whole and of any other race taken as a whole" (*The Mind of Primitive Man*, 1938, p. 270).

In so small a book it was of course impossible to go into details of anthropological history, but a little more might have been done in this direction. Although Herskovits occasionally refers to precursors and contemporaries, there are times when Boas is assigned the role of a mythical culture-hero, bringing light out of Cimmerian darkness. This is unfair to other thinkers in the field and was certainly not Boas' own view of the matter, considering his tributes to Tarde, Bogoras, and others. Though little may be ascertainable on the subject, some reference might have been made to the personal contacts with Virchow and Tylor, to Waitz's earlier treatment of the relation between race and culture, to Galton's injection of the principle of individual variability into the scientific arena. On the other hand, the author felicitously touches on Boas' pedagogy and his relations with students; Herskovits' insistence that there was no "Boas school" is especially commendable. Altogether his compact treatment provides a good first aid towards the comprehension of a great scientist not easily understood.

ROBERT H. LOWIE

Department of Anthropology
University of California at Berkeley

Squaring the Circle and Other Monographs. E. W. Hobson *et al.* New York: Chelsea, 1953. 361 pp. Illus. $3.25.

UNDER this innocent title (and the three-word abbreviation on the spine makes it even a deceitful title) are reproduced four minor classics from the by-ways of mathematics. Why they are jointly selected, what the connecting thread is, and what determined the highly anachronic order of presentation, are questions that may puzzle some readers, and the absence of a modern preface to give finish and cohesion to an otherwise excellent book is to be regretted. The title essay was originally a set of special lectures delivered in 1913 by the late E. W. Hobson, the English authority on functions of a real variable and on spherical harmonics. He was a don who lectured as formally and precisely as he wrote, a course in his hands being a continuously unfolding exposition. They say in Cambridge that one of his class lectures began, "This being so. . . ." His skill is apparent in this succinct history of the number π, easily the best there is, yet little known

and seldom quoted. The second essay, "Ruler and Compass," written ca. 1916 by another English mathematician, Hilda Hudson, known for her work on Cremona space transformations, is an analytical and geometrical investigation of how far Euclidean constructions can take us. It is as thorough-going as it is constructive.

Of the remaining two essay topics, one is more immediately applicable, and the other more abstract, than the geometrical openers. Sir Alfred Kempe's "How to Draw a Straight Line: A Lecture on Linkages," takes us back to 1877. At that time Peaucellier's recent solution of the long-standing problem of devising a link motion that would trace a true straight line had just been made use of in the ventilating plant in the British Houses of Parliament, and the whole subject was engaging wide attention. Kempe made himself a leading exponent of it, and many fascinating linkages are illustrated here—including one that will trisect any angle.

The last essay (the third in the book) is also the most modern and most esoteric. Here we enter the beguiling Alice-world of pathological curves, some of which bound a small finite area and yet are infinite in length, while others entirely fill squares, cubes, and hypercubes, and some cross themselves at all points. A. N. Singh, now professor of mathematics at Lucknow, wrote "The Theory and Construction of Non-differentiable Functions" in 1935. It is a fine and well-documented account of the class of continuous functions whose graphs have no tangents at any point. Weierstrasse's establishment of the existence of such curves in 1860 was a landmark, and more than one eminent contemporary did him the honor of trying to disestablish his proof.

By making available these four works, all too long out of print, the publishers have done a worthy job.

N. T. GRIDGEMAN

Division of Applied Biology
National Research Council
Ottawa, Canada

The Revolution in Physics. Louis de Broglie. Ralph W. Niemeyer, Trans. 310 pp. $4.50. Noonday Press, New York. 1953.

THIRTEEN years ago (SCIENTIFIC MONTHLY, **50,** 78 [1940]), in criticizing de Broglie's book *Matter, and Light—The New Physics,* the present reviewer wrote: "It is a great pity, however, that the book is not written 'from the beginning to the end,' but represents rather a collection of different separate lectures and addresses cemented together by a number of specially written chapters. . . . There is hardly any doubt that much more satisfactory results could be obtained if the author would find time to write a consistent presentation of the present state of the problem, instead of patching the book together from different originally disconnected pieces."

The new book by Louis de Broglie completely fulfills the hopes of the reviewer. It is excellent, masterful presentation of the evolution through which the science of physics went in the course of the last half century and the present status of the ideas concerning space, time, and motion. It contains a skillful analysis of the origin and development of Einstein's theory of relativity, and the sequence of events which leads to the present wave-mechanical theory of atomic phenomena, the cornerstone of which was laid by Prince de Broglie himself.

We can only wonder: "Reviendra-t-on au déterminisme en physique quantique?"

G. GAMOW

Department of Theoretical Physics
George Washington University

Studies in Econometric Method. Wm. C. Hood and Tjalling C. Koopmans, Eds. New York: Wiley, 1953. xix + 323 pp. Illus. $5.50.

THE past years have seen the publication of several introductions into the systematic quantitative study of economic phenomena, better known perhaps under the name of econometrics. Since economics is among the older and more articulate of the social studies, and since econometrics in its attempt to develop and promote scientific method has encountered rather intriguing and complex situations sui generis, not always parallel with problems elsewhere, some degree of familiarity with the problems of the econometrician may be rewarding for those doing social research in other areas, and also for the research worker in the physical and biological sciences, inasmuch as he is interested in scientific method as such.

The book reviewed here is generally on a more advanced and mature level than other available summaries of econometric method, although it is more narrowly conceived. It is a summary descriptive of the particular approach by but one, though probably the most widely known, school of econometricians. The *Studies in Econometric Method* are in essence an interim progress report on the work of the Cowles Commission. They consist of ten separate contributions, three of which have previously appeared as articles in various learned journals. According to the preface, the intention of the editors was in part to give "an exposition of some of the problems treated more technically in Cowles Commission Monograph 10." This modest statement, however, should not mislead the reader into assuming that the present volume is not technical or that it makes easy reading. Quite the contrary: being employed in the discussion of model building in an area where both number of variables and complexity of interactions are overwhelming, neither conceptual framework nor quantitative language can be simplified below a certain point. The skeptical reader may, of course, wonder whether—in view of the nature of the problem and the state of our knowledge—this point has not been set too high.

An attempt toward an answer to that question is implied in chapter I, a most lucid example of describing objectives and manner of constructing conceptual models in economics. This chapter together with the following two, on identification, will probably be of

greatest interest to the general reader. Chapters IV to IX deal primarily with various questions of statistical estimation as they occur especially in connection with the coefficients in systems of stochastic equations. Chapter X is computational in character and gives a detailed theoretical and procedural account of the way in which the numerical values of the maximum likelihood estimates were formed. This chapter and its appendices are likely to be of direct interest to the operating statistician.

The present collection of papers reflects courage and vision as well as a quarter century of painstaking and meticulous labor by those who have at various times been members of the staff of the Cowles Commission. They should be stimulating and sustaining food to him whose roving mind is challenged by the outlook of catching glimpses of the model building artist at work—whatever the area in which the workshop may be located. This book should also prove provoking to those interested in the development of inductive reasoning in general, and of the application of multivariate statistical analysis in particular. Those, on the other hand, who are looking for a single and comprehensive introduction into econometrics as a discipline, in order to enlarge their store of information, may find a plainer and better balanced diet more beneficial.

J. E. MORTON
Cornell University

Plough and Pasture: The Early History of Farming. E. Cecil Curwen and Gudmund Hatt. New York: Schuman, 1953. xi + 329 pp. Illus. + plates. $5.00.

IT would hardly be correct to call this book a collaboration between a prehistorian and an ethnographer, for the two parts of *Plough and Pasture* stand quite independent each of the other. Part I, Prehistoric Farming of Europe and the Near East, is the work of Curwen, an English antiquarian, and Part II, Farming of Non-European Peoples, is by Hatt, an ethnographer. As authors, Curwen and Hatt unfortunately are strangers to each other. Consequently, the great defect of their book is that it lacks unity, is devoid of integration. As such it is an artistic failure.

One might demur that a book on a scientific subject need not measure up to artistic standards. But *Plough and Pasture* must, because it is not a scientific report but rather a simplified synthesis for the layman of the scientific findings of other researchers.

Although each author utilizes for the most part different bodies of data, there is still a good deal of redundancy as each cites identical facts without apparent awareness that the materials have already been or will be used by the other. Curwen uses one system of footnoting, Hatt another. Curwen uses "corn" in the English meaning of farinaceous seeds; Hatt uses it in the American meaning of maize. Curwen dogmatically asserts that Civilization must be the result of diffusion from one original center (his difficulty is that he thinks of a civilizational complex as being created en bloc rather than as an accretion from many sources) and that, concomitantly, agriculture is "likewise to be regarded as having been diffused from one center within the area" (p. 23). Hatt, who has a more sophisticated understanding of cultural dynamics, writes, "we can hardly avoid the impression that there must have been several centers of plant domestication in Ancient America" (p. 199).

It is not to be denied that *Plough and Pasture* brings together a fair amount of interesting factual materials on proto-historic plant distributions, on the archaeology of cultivation and animal domestication, and on the gardening proclivities of recent and contemporary primitives. The data are so simplified, however, that the appeal of the book will be limited to the novice outside the fields of botany and anthropology.

Hatt's summaries of the current material and thinking on ethnobotany and ethnozoology are sound and correct, as far as they go. But he missed a most significant hypothetical contribution made by Ralph Linton some years ago. (In: *The Maya and Their Neighbors.* C. Hay *et al.*, eds. New York, Appleton-Century, 1940, pp. 32–40). Linton, who emphasizes the importance of protein as a complement to starch in an adequate energy-producing diet, suggests that the lowly bean met this need and is the real key to American high cultures. Maize is merely more spectacular to look at but not dietarily nearly so significant as it seems (note that we convert most of our maize to protein through beef and hog feeding). Hatt, had he run across Linton's suggestion, would surely have qualified his assertion that "Maize is probably not the oldest cultivated plant in America, but it is certainly the most important. It was the maize cultivation that made possible the magnificent cultural evolution in the Andes, and in Central America, Mexico and the American southwest area" (p. 207).

E. ADAMSON HOEBEL
Department of Anthropology
University of Utah

Algal Culture from Laboratory to Pilot Plant. John S. Burlew, Ed. Washington, D. C.: Carnegie Institution of Washington, 1953. ix + 357 pp. Illus. Paper, $1.25.

THE human race owes its continued existence to the evolution of mechanisms whereby green plants were (and are) able to synthesize foods from simple inorganic compounds. These mechanisms involve first the use of the pigment chlorophyll in converting water and carbon dioxide into simple sugars, utilizing the energy of sunlight. The sugars may then undergo chemical transformations that result directly or indirectly in proteins, fats, protoplasm, cell wall constituents, and many other kinds of substances. Human beings live well or poorly or starve, depending upon the availability, directly or indirectly, of plants or plant products containing such organic compounds. The specter of hunger and famine has stalked the earth since recorded history, and even today many peoples exhibit effects of malnutrition and exist on the verge of starvation. This

means that foods and their derivatives are of prime concern to national and international well-being.

It is not likely that test tube syntheses will proceed far enough in the near future to add materially to our food sources, although great strides have been made in the synthesis of compounds found formerly only in nature. In recent times many scientists have turned their attention more and more to a study of microorganisms as sources of useful compounds or as aids in their formation. We are familiar with yeast and alcohol, bacteria and lactic acid, molds and antibiotics, and now we have a report of a number of investigations on the behavior and productivity of a certain alga, belonging to a great group of organisms (many are microscopic) bearing chlorophyll.

Many microscopic algae are aquatic and have been grown successfully in small laboratory cultures for years. Such cultures have elucidated many things concerning algal behavior, the composition of culture solutions for different algae, relation to light and other environmental factors, and the nature of some of the organic substances made in these green plants. It has long been felt that the algae offered a prodigious source of food and energy for mankind, if they could be economically harvested. We have in the main profited from this food source only indirectly: eating fishes and other aquatic animals that feed upon the algae.

In the last decade or two attention has been given in several research centers to the problems of growing algae in experimentally maintained mass cultures. Under the editorship of John S. Burlew there is recorded in this volume the results of growing algae on a "laboratory to pilot-plant" scale, chiefly under the auspices of the Carnegie Institution, with supplementary reports from Japan, Germany, and Israel. A foreword by V. Bush is followed by introductory chapters on the Current Status of the Large-Scale Culture of Algae (Burlew) and on The Need for a New Source of Food (Spoehr). The remaining twenty chapters deal with light, temperature, and growth effects; protein, fat, and sterol content; engineering requirements of mass culture; chemical composition, nutritional and industrial potentialities of algae, particularly applied to experimental work with the microscopic *Chlorella*, especially *C. pyrenoidosa*. Some forty scientists collaborate in the report of their investigations with this alga.

It has been learned that dried algal cells may have a high vitamin value and contain over fifty per cent protein that is easily digested and that contains the ten essential amino acids. The dried *Chlorella* cells have a taste something like that of raw pumpkin or raw lima beans. Thus if the experimentation continues to progress, it would appear desirable to add home economists to the research teams of biologists, chemists, and engineers to find out how to cook the material. Large-scale cultures of algae can now be maintained over considerable periods of time at a productivity equal to that at the height of their growing season. The algal cells are constantly supplied with as much raw material, necessary for growth and multiplication, as they can utilize. Light of high intensity cannot, however, be used by these cells. A uniform suspension of cells can be maintained by removal of some of the accumulated cells.

A quart of a relatively thin suspension of *Chlorella* may have a population of twenty billion cells. During vigorous growth in summer this number may be doubled in a single day. It is estimated that pilot plants of *Chlorella* might produce an annual yield equal to seventeen and one-half tons per acre, using present-day smaller surface areas as a basis of extrapolation. It is thought that naturally occurring bodies of water present too many difficulties of control and harvesting to serve as practical sources of algal harvests for use either as food or sources of materials important in diet or industry.

These interesting and sometimes startling results of investigations so far analyzed are samples of data presented in the carefully written chapters, sometimes quite technical, objectively reporting the experimentation, and pointing out both prospective values and limitations. There is a comprehensive bibliography of literature dealing with the mass culture of *Chlorella*, and a good index is provided.

Lewis Hanford Tiffany
Department of Biological Sciences
Northwestern University

American Constitutional Custom. Burleigh Cushing Rodick. New York: Philosophical Library, 1953. xi + 244 pp. $4.75.

It is fortunate, indeed, that Professor Rodick was moved to publish his notes on the origins of the principles underlying the form of government established by the Constitution of the United States. His analysis and interpretation of the habits, custom, and tradition that guided the members of the Convention of 1787 is extremely valuable to historians, political scientists, and to all who strive to understand the effects of economic and social factors on the development of the traditions of freedom and authority. His account of early American constitutional custom is distilled from his vast knowledge of the subject, and from the conclusions he has reached after many years of intensive labor in the field. Despite what he terms the temporary influence of Jefferson and his followers, it was the customs of English liberalism rather than French that prevailed during the early years, and reached its finest flower in a union of freedom and authority in "sound and just proportions." Professor Rodick will concede that the Jeffersonian influence still persists, and waxes and wanes with the swing of the political pendulum. We have just emerged from a period of war, preceded by an economic depression, during which the power of the executive dwarfed the legislative. The reaction has now begun, and the legislative branch, by statute and by proposed constitutional amendment, seeks to minimize and subordinate the executive. The danger to the preservation of the balance achieved through the union of contending forces seems clear, but such a movement, it is hoped, may be no more than the "constant interplay between the forces of continuity and change." If custom is really a forgotten fac-

tor in the founding of the government, nevertheless it is a highly important one. A written document may be changed overnight, but habits and custom remain. Tradition may be ignored but never obliterated or repealed. Professor Rodick has performed a monumental task in compressing the result of his studies of the subject, during the colonial period to Jefferson, into 140 pages of text. He has also included a wealth of citations and notes, in support of his text, and a valuable bibliography.

PHILIP B. PERLMAN

Washington, D. C.

Prehistoric Settlement Patterns in the Virú Valley, Peru. Gordon R. Willey. xxii + 453 pp. Illus. + maps + plates. $4.00. U. S. Government Printing Office, Washington, D. C. 1953.

ALL too commonly, archaeologists have worked as if their discipline were a special earth-science, concerned only with the physical properties of objects excavated from the ground. Willey's monograph is a most encouraging illustration of how basic features of social development can be recognized in the prehistoric remains of people who left no written records. It is also proof of the value of teamwork in cultural science.

The Virú Valley, an oasis on the arid coast of northern Peru, has been inhabited by human beings for at least 5000 years. In order to understand the nature of human occupancy and the changes of local cultures, the valley was studied cooperatively by several North American and Peruvian institutions. Special stratigraphic and seriation studies provided a historical ceramic framework of period sequences, so that pottery types could be used to date villages, mounds, temples, public buildings, forts, roads, and irrigation works. From these data Willey inferred the evolution of interfamilial and community patterns, community and intercommunity religious institutions, and the economic and militaristic factors underlying local sociopolitical integration.

Willey divides the prehistory of the Virú Valley into eight periods differentiated by conventional ceramic criteria. The first two periods were characterized by family or small village units who depended more upon fishing than farming. Then, maize agriculture and irrigation were introduced. The subsequent development of ceremonial centers in the form of temples and later of artificial pyramids topped by temples, as well as of public buildings and fortified sites, seems closely related to need for coordination in the basic irrigation economy. The expansion of irrigation, increase of population, and enlargement of communities and their clustering around ceremonial, public, and perhaps fortification centers were clearly interrelated.

Willey's monograph is one of the most convincing studies in several decades that archaeology and ethnology are merely specialized techniques that contribute to basic cultural research. This, however, is but a beginning in a new conceptual orientation of archaeology. Willey's major groupings of periods are given such noncommittal names as "Formative," "Classical," and "Expansionist." There still remains the question of what diagnostic patterns and development processes underlie these periods and of how far they have cross-cultural and comparative significance.

JULIAN H. STEWARD

Department of Sociology and Anthropology
University of Illinois

Life on the Earth. Rose Wyler and Gerald Ames. 143 pp. Illus. $2.50. Schuman, New York. 1953.

WHEN I had finished reading this book, I still wondered who was it written for: is it a child's book or is it for the adult layman? The book is a mixture. Some parts seem ideally suited for children (or at least ideally suited to what an adult thinks children would understand and enjoy); and other parts, particularly those touching on chemistry and physics, seem certainly beyond the grasp of a young child.

The writing itself is remarkably clear. The style is the utmost in simplicity, consisting of short sentences that go straight to the point with an economy of words. There is no pretense of any poetry in the prose, but the result is not unpleasant, and out of the starkness come vivid and straightforward impressions.

The examples the authors give of living phenomena are interesting, and in the large majority of the cases essentially accurate despite the simplicity of statement. There is much worthwhile information in this small volume such as, for instance, facts about the water-storing ability of cacti or the relation of metabolic rate to body size in animals—quite enough facts for the meaning to emerge.

To my mind the failing of the book lies in the disorder of these facts. Both their selection and arrangement produce a genuine feeling of chaos. The book itself is extremely short, yet there is hardly a subject in biology that is not mentioned in it. There is even a section on paleontology and at the end a few pages on human evolution and the supremacy of man. The sequence leaves one numb with confusion. There may have been some method in the planning of the chapters, but it had become totally obscured by the time it was written. It is unfortunate that with so simple a style of writing, the authors did not take one topic from the multitude and develop it carefully and coherently.

JOHN TYLER BONNER

Department of Biology
Princeton University

Climate, Vegetation and Man. Leonard Hadlow. 288 pp. Illus. $4.75. Philosophical Library, New York. 1953.

THIS is a textbook in geography for elementary school children and has no interest for adult readers except in its manner of presentation. The author has used numerous clever, well-executed diagrams and skillfully contrived exposition to make clear the subjects

that are usually difficult for children. A chalk dot on a football illustrates the difficulty of describing position on the earth and an enormous glass dome with curved ladders meeting at the top shows how it is done. The astronomic motions of the earth and their consequences in causing day and night and the seasons are not easy to make clear to children, but in this book the author has succeeded.

The source of energy of the sun is described as being the same as that in the hydrogen bomb, the "fusion, or union, of hydrogen particles into helium. . . . From this solar power-house, the energy streams out through space, and on reaching the earth is converted into life-giving heat. Gradually the sun is growing bigger and hotter, and eventually, more than 10,000 million years hence, it will be far too hot for life to exist on earth." This savors of the Space Cadet and suggests that the modern schoolchild knows many things that his parents never dreamed of.

A chapter on meteorology is entitled War and Peace in the Air. The military analogy is continued even to the captions on the figures. The classical development of the polar front, called "the battle of the depression," is shown in four stages which are appropriately labeled: "The opponents line up opposite each other," "The preliminary skirmish," "The battle in full swing," "Polar air victorious."

This is a book for British schools and is so filled with references to English localities and there are so many obscure literary allusions that it could not serve American children. One wishes for a similar book, however, that could be used.

C. W. THORNTHWAITE

The Johns Hopkins University
Laboratory of Climatology
Seabrook, New Jersey

Brown Coal: Its Mining and Utilization. A series of postgraduate lectures delivered in the School of Engineering, University of Melbourne (Australia). P. L. Henderson, Ed. Melbourne University Press; Cambridge University Press, New York. 1953. xi + 351 pp. Illus. $7.50.

THIS is a concise and up-to-date book on the nature, distribution, mining, preparation, and utilization of brown coal. In the first lecture attention is called to the outstanding differences in the properties of brown and black coals. The former is earthy in nature, has a high water and oxygen content, deteriorates and slacks in storage, and is subject to spontaneous ignition. The term, "brown coal," is used in this book for coals which are brown in color and contain more than 30 per cent moisture. It embraces both the brown coal and the lignite of the American Society for Testing Materials classification.

A good picture is presented of present-day knowledge of the chemistry, physical structure, and occurrence of brown coal in the world. Most of the deposits are mined by open-cut methods. These operations, both for removing the overburden and for winning the coal, are well described and illustrated. The utilization of raw brown coal for steam generation is discussed, showing the relation of the composition and structure of the coal to the type of stoker and furnace required for most efficient combustion of the fuel.

The lectures on the Briquetting of Brown Coal and on the Use of Brown Coal and Briquets in Victorian Industry are interesting and important because briquetting is practically the only means whereby the earthy soft brown coals can be converted to a stable lump fuel that may be transported, stored, and burned in ordinary stoves and hand-fired furnaces. It was discovered in Germany, nearly 100 years ago, that the earthy brown coals could be briquetted at high pressure, without the addition of any binder, after drying off most of the water. This led to the development of the important brown coal briquet industry of Germany. The growth of briquetting in Germany and its subsequent application to Australian brown coals is well described with numerous illustrations in this book.

The last four lectures give an excellent historical and technical account of the development in Germany of the Lurgi process for the pressure gasification of brown coal with oxygen and steam, and also of gasification in fluidized beds.

The book will be of special value to English-language readers to whom the extensive German literature on brown coal is not available.

ARNO C. FIELDNER

Bureau of Mines
U.S. Department of the Interior

The Study of Human Nature. David Lindsay Watson. Yellow Springs, Ohio: Antioch Press, 1953. x + 262 pp. $3.50.

THE main thesis of this book is that, for purposes of an adequate knowledge of human nature, the real hope lies in the "*insight, intuition, flair, sixth sense,* or what you will" which we associate with the great literary artists, and not with the mechanized methods and procedures of so-called social science. The idea is familiar enough, but it is presented here with notable vividness, vigor, and illustrative detail. While I have a good deal of sympathy with Dr. Watson's impatience with that unimaginative, plodding, and seemingly humorless type of social scientist who takes himself and his "results" rather too seriously, regarding these as the last word on the human situation he happens to be dealing with, I cannot but think that his strictures on social science are basically irrelevant. For example: would he discount the Kinsey reports because they restrict themselves to what appear to be "facts" and ignore the variety of individual feelings and attitudes that underlies the facts? Surely the artistic insights he rates so highly are not the outcome of "a revising and refining of the concept 'science'," but the result of a point of view and an aim quite different from those of science.

There would appear to be irrelevance again in his

attack on the notion of objectivity. Even the physicist imposes his special methods and operations on the realities he must deal with. Admitted, but the layman (whom Dr. Watson tells us he is concerned to reach) should not be misled into thinking that, because scientists are human beings, the distinction between objective and subjective is not both valid and important. (Incidentally, I would be inclined to tell the layman that the despised procedures of social science could make short work of the claim that handwriting "gives us clues to mental and moral qualities.")

If Watson's thesis had been that, in order effectively to *apply* the findings of social science to a particular culture, philosophic and aesthetic considerations must be investigated with whatever objectivity is possible, I would be in entire agreement with him. The impression he leaves, however, is that he considers social science in the ordinary sense as simply an obstacle to adequate understanding.

The book closes with a short chapter headed "Afterthoughts," which reads like an evangelical sermon. One is left wondering why it was added. On the whole, I would say that anyone who is more interested in having his thinking stimulated than in having it clarified will find this vivid and very repetitious book rewarding reading.

JOHN MACDONALD

Edmonton, Alberta, Canada

Experimental Studies in Psychiatric Art. E. Cunningham Dax. Philadelphia: Lippincott; London: Faber and Faber, Ltd., 1953. 100 pp. Illus. $5.00.

THIS small volume is an interesting addition to the increasing literature on the "art" of the psychotic patient. Calling this book studies in art may be somewhat misleading: these productions are not evaluated according to their artistic merit, but are to be considered as a graphic expression of the patient's illness. The study deals with paintings produced by psychiatric patients and the effect of their listening to music.

The structure of the paintings is investigated. The author summarizes some of their characteristic features as found in the various emotional disturbances. The findings are simplified and purely descriptive. Very little attention is paid to the dynamic content of the productions.

Dr. Dax sets up interesting experiments of the influence of music on the cardiovascular system and other bodily activities. After listening to certain classical selections, the patients were required to paint their impressions. It is concluded that music seems to influence the mood of the psychotic patient more than any other function, such as the use of colors or "artistic merit."

Finally, the dependence of the painting's structure on personality integration is demonstrated. Brain injury (following operations) leads to structural disintegration which reintegrates as results from the operation subside.

This little book seems to be primarily written for the educated lay person. It is simple and clear. Some of the experiments may offer some stimulation to the psychiatrist and clinical psychologist. The author's caution to avoid premature conclusions is certainly commendable. But it may also keep him from a deeper analysis of his findings. He is eager to produce "scientific validity" of his findings. Therefore, he standardizes the conditions under which his patients are required to paint. But such restrictions are apt to inhibit the spontaneity of the productions which appears to be of prime importance.

In general, this book is a conservative approach to an interesting problem. It opens up some stimulating thoughts, possibly a few new avenues, and offers but few answers.

OTTO BILLIG

Department of Psychiatry
Vanderbilt University

Twenty Years of Psychoanalysis. Franz Alexander and Helen Ross, Eds. New York: Norton, 1953. 309 pp. $3.75.

A SYMPOSIUM held at the Chicago Institute for Psychoanalysis is represented in *Twenty Years of Psychoanalysis.* The volume is divided into two parts. The first section contains the proceedings of the scientific meetings held in Chicago, October 11, 1952, to commemorate the twentieth anniversary of the founding of the Institute. These papers deal with the influence of the basic concepts of psychoanalysis on medicine and medical teaching in general, on psychiatry in particular, and on the social sciences. Formal discussions follow the papers. The second section is devoted to four papers that present an account of the specific training and research activities of the Institute during the two decades of its existence. In addition, there is a list of the publications from 1932 to 1952 by members of the Institute's staff during the period of their association with it, thus rounding out the history of the twenty years.

In the first article of the book, Franz Alexander presents a general survey of the history of the Institute's goals, emphasizing research as the primary objective. In teaching, he states, the ideal was to stress from the beginning that instruction should be based on the students' own observations. Alan Gregg has written brilliantly on the place of psychoanalysis in medicine. There follow articles on the impact of psychoanalysis on training in psychiatry, by Maurice Levine; present trends in psychoanalytic training, by Martin Grotjahn; an interesting account of psychoanalysis as a basic science, by Lawrence S. Kubie; psychoanalysis and the biological sciences, by I. Arthur Mirsky; and psychoanalysis and the social sciences, by Talcott Parsons. Like all symposia, this volume is of interest primarily to the special student of the subject.

PHILIP R. LEHRMAN

25 Central Park West
New York City

LETTERS

THE RESPONSES OF COLLEGE STUDENTS TO A QUESTIONNAIRE ON ANIMISTIC THINKING

In a recent issue of The Scientific Monthly, Dennis[1] has presented evidence that a large proportion of college students accept as having the property of being alive many classes of objects which certainly do not have that property according to any scientific definition of life. When asked whether such objects as a lighted match, the sun, a pearl, and the ocean were alive, as many as 45% of college students answered in the affirmative for one or more of the items. The students were also asked to write explanations of their answers, and some of these explanations, as cited by Dennis in his article, leave no doubt that his subjects were thinking animistically.

However, the task given these students may have been too sophisticated. When asked of a lighted match, "Is this alive?" a college student may not be aware of the implications of, or the possible qualifications of, alternative answers. The present writer, acting upon the invitation by Dennis to verify his observations, has constructed a questionnaire which permits the respondent to select among animistic and nonanimistic alternatives as answers to the kind of question posed by Dennis. Five such questions in multiple choice form have been placed among five other questions so that the exact purpose is disguised to some degree. This questionnaire has been administered to 163 students in psychology courses and 40 students in second year zoology. The psychology sample contains the following subsamples: 20 freshman nurses; elementary psychology, 35 arts and sciences students, 40 business majors, and 30 art majors; 38 advanced psychology majors.

The printed instructions and items of the questionnaire follow. The heading of the questionnaire, "A.T. Survey, Form A," gave no clue as to its contents. Shown after each response in parentheses are the percentage responses obtained from the psychology sample and the zoology sample, respectively.

Here are some questions about common objects and events in the world. Some of the questions are very easy to answer; others are very hard. Please answer each question seriously, even if you think it is very simple. For each question, select the ONE answer which you think BEST; then write the corresponding letter in the parentheses at the left of the question.

1. ( ) Does an earthworm have emotions?
   A. Yes, because it is a living thing. (11.1–8)
   B. Yes, because it struggles about when hurt. (11.1–0)
   C. It is hard to decide because it is so different from the higher animals. (29.4–20)
   D. Probably not, because it is such a primitive creature. (32.5–60)
   E. No. It is not a conscious being. (15.9–13)
2. ( ) Many ships are lost at the bottom of the sea. We cannot find them. Do you think the sea itself knows where they are?
   A. Yes, because the chemicals of the sea come in contact with them and know where they are. (0.0–0)
   B. Yes, because the sea rubs over them and knows them to be there. (0.6–0)
   C. Probably not, because the sea does not have any nerves of its own. (9.2–13)
   D. No. There are so many sunken ships the sea could not possibly know about them all. (0.0–0)
   E. No. The sea is incapable of knowing anything. (90.2–88)
3. ( ) Many people seem to be able to go into a trance in which they have contact with the spirits of the dead. Is this possible?
   A. Yes. Spirits of the dead are eager to communicate with their loved ones. (0.0–0)
   B. Yes, but only for those who are willing to believe in the reality of spirits. (10.4–11)
   C. Probably, but sometimes unscrupulous persons just pretend to make contact with spirits in order to "fleece" unsuspecting victims. (6.1–8)
   D. Probably not. Most evidence that such things really happen is pretty shaky. (61.4–62)
   E. No. If there are such spirits, nobody can contact them. ((22.1–20)
4. ( ) A person being operated on is given a deep anesthetic. What happens to the pain?
   A. The anesthetic absorbs the pain. (1.2–0)
   B. The pain is still there, but the person does not feel it. (31.3–20)
   C. The nerves which transmit pain are deprived of their effectiveness. (67.5–75)
   D. Pain is not a real thing, but depends upon imagination, which is absent under anesthetic. (0.0–5)
   E. The pain is kept inside the nerves, so it cannot get out to be felt. (0.0–0)
5. ( ) When an automobile tire blows out, does the tire feel it?
   A. Yes. The tire feels the great and sudden reduction of internal pressure. (0.6–0)
   B. Yes. Rubber molecules are very active, and feel the rending and tearing of the blowout. (1.8–8)
   C. Probably not. The rubber in the tire has been dead a long time since it was part of a tree. (1.8–3)
   D. No. Once the tire blows out, it is too dead to feel. (0.0–0)
   E. No. An automobile tire cannot feel anything. (95.8–90)
6. ( ) A man has his hand cut off, and a month later he complains about pain in the missing fingers. Why?
   A. The lost hand really takes a long time to die, and it is protesting. (0.6–0)
   B. Nerves which come from where the hand once was are still active. (67.5–60)

C. The man just imagines the pain, which really isn't there. (26.4–33)
D. No part of the body can be cut off without destroying a part of the mind. (2.4–8)
E. Objects which fill the space where the hand used to be come into conflict with it. (3.1–0)

7. ( ) Is the sun alive?
A. Yes, because it gives off flames, which indicate life. (0.0–0)
B. Yes, because it gives forth energy. (5.5–0)
C. Yes. It is not breathing, but it is pulsating, scientifically living and ever changing. (22.1–11)
D. Probably not. It is doubtful that the sun is really alive. (6.1–15)
E. No. It is not a living thing. (66.3–75)

8. ( ) What is the difference between living tissue and things that are not alive?
A. The living tissue changes, while the non-living things cannot. (39.9–27)
B. Living tissue contains a special life-spark breathed into it by a greater power. (16.0–11)
C. Living tissue has both molecules and spiritual existence. (12.3–8)
D. Nobody has really determined satisfactorily what the basic difference is. (29.4–52)
E. There is no difference worth mentioning. (2.4–3)

9. ( ) The natural, oyster pearl was once in a shell in the sea. When the water moved over it, could the pearl feel the movement?
A. Yes. It was a growing thing much like a fetus in the mother's womb. (1.8–0)
B. Yes. The pearl was part of a living thing. (3.1–0)
C. Probably, but only indirectly through the senses of the oyster. (9.2–5)
D. Probably not. A pearl is just a kind of growth in a shell. (36.8–45)
E. No. A pearl could never feel anything. (49.1–50)

10. ( ) When a plant is cut off, it wilts. Does the plant feel depressed when this happens?
A. Yes. Its gradual reduction of living force makes the plant suffer. (0.6–3)
B. Yes. The cells shrink and become dry, and cause a depressed feeling. (3.8–3)
C. Probably, but only in a very dim sort of way. (2.4–8)
D. Probably not. Plants do not have consciousness. (30.0–30)
E. No. Such feelings are not possible for plants. (63.2–57)

For the study of animistic responses, the critical items are Nos. 2, 5, 7, 9, and 10. Of these, 2, 7, and 9 are taken from the study by Dennis, and the highly animistic alternatives are paraphrased from statements actually made by his subjects. The other two items were added by the present writer. This preliminary form of the questionnaire obviously has serious faults, among them the total lack of attractiveness of some of the alternatives. By far the best "mislead" is found in item 7, C, which attracted over a fifth of the respondents in the psychology sample.

To afford greater comparability with Dennis' findings, an analysis was made of the number of individuals who selected one or more clearly animistic responses to any of the questions. Considered animistic were responses A, B, C, and D on Items 2 and 5; A, B, and C on Items 7, 9, and 10, and responses A and E on Item 6. In the psychology sample, 58 students (35.6%) selected one or more of these alternatives. In the zoology sample, 11 students (27.5%) made a similar selection. If to these cases are added those who, because they seem rather doubtful of the true distinction, select response D on Items 7 and 10, these two percents become 54.0 and 52.5, respectively.

These results substantiate those by Dennis, and leave little doubt as to the fact that a distressingly large proportion of our college students are unable to make a precise discrimination with regard to the nature of life. Note the responses to Item 8 of the questionnaire, if still in doubt as to the ability of many students to make a good distinction. It is admitted that this particular item may arouse controversy. Many students wrote on the reverse of their questionnaire some additional answer, usually involving some statement about protoplasm or physiological processes. However, the largest proportion of psychology students selected alternative A, a palpably false answer.

In one respect these results fail to confirm Dennis' findings, in that more animistic responses occur among the advanced zoology students than his data on biologically trained students would lead one to anticipate. Using a list of items made up of a match (lighted and unlighted), an electric clock, the sun, the wind, gasoline, the ocean, and clouds, and asking the single question about being alive, Dennis found that 37 to 48 percent of students like those in the present psychology sample gave at least one animistic answer. When the same experiment was tried with 71 college sophomores in the third semester of an integrated science course (in which the current emphasis on biological principles was very strong), he obtained only twelve percent such answers. Rather than believe that the education of the present advanced zoology group has been atypical, it is conjectured that presentation of the questions in simple "yes-no" form may be less likely to lead such students off the track of the precepts learned in their courses than is the multiple-choice type used here.

The present writer fears that here is added one more howl to the hullabaloo about our educational system, which, so we are told again and again, fails to teach our young folk to spell, to cipher, to comprehend the American Way, or to keep house (the relative exacerbation of the deficiency depending upon the specialty of the complainant). Yet here we have evidence that a significant minority of our college students has not even learned "what life is all about." To some degree, at least, their thinking seems about as useful for a civilized life as that of a Trobriand Islander. Like the

educational deficiencies which have a longer reputation, this one probably has no ready solution, but the investigations pioneered by Dennis show us where another educational battle-line must be drawn.

C. W. Crannell

Department of Psychology
Miami University
Oxford, Ohio

Reference

1. Dennis, W. *The Scientific Monthly* **76**, 247 (1953).

SETS OF THREE MEASUREMENTS

Among the excellent articles in the September issue of Scientific Monthly the most challenging was, in my opinion, the paper by W. J. Youden, "Sets of Three Measurements." It is no criticism, but rather greater emphasis of a thought which Dr. Youden made implicitly that prompts me to write you this letter.

Measurements are made with instruments. Consequently there are three factors involved in every measurement: the object to be measured; the measuring instrument; and the person who makes the measurement. Only the complete coordination of these three factors will furnish satisfactory results.

While the physical scientists are generally aware of the objective side of the measuring process, namely the behavior of object and instrument, and are taking into account the limitations of accuracy resulting from these factors, they only too often overlook the mental and emotional changes that are taking place in the measuring person, especially during difficult, exacting, or long drawn out measuring operations.

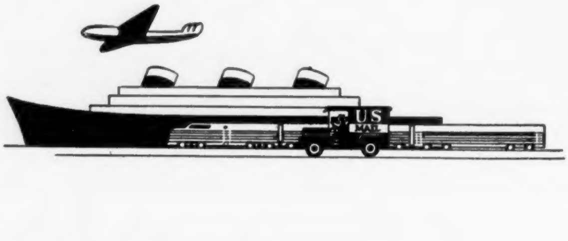
Whoever experienced the mental stress and emotional strain of a scientist looking for hours at a pointer on a scale while performing in his mind estimations and calculations as to the "proper behavior" of this inanimate agent; whoever felt the satisfaction or frustration which after a long period of patient waiting may evolve from the reading of, say, the third digit after the decimal point of the unit of measurement—he will agree that, however much we should want to exclude our personality for the sake of "objectivity," we shall never be able to achieve this aim completely.

Consequently, the psychological factors may play a greater part in the accuracy of our measurements than we are generally inclined to admit. Take, for instance, the set of three measurements which is the subject of Dr. Youden's article. The readings will be made in time sequence, even when several independent experiments are running simultaneously. Thus we may assume that the first reading will condition the research worker towards the second one, and the second one toward the third one. If the experiments are not made simultaneously, but in a time sequence, we may assume that each subsequent test will be made with greater accuracy than the preceding one by way of exclusion of errors detected during the performance of the preceding operations. It is as though the investigator is trying to approach the "truth" in an asymptotic way. And how often does it happen that the pointer comes to rest just at the midpoint between two of the third digits, in which case we choose in all honesty the one that is nearer to the results of preceding measurements or our mathematical calculations?

If we add to these psychological factors unavoidable changes that take place in the measured object during the time of observation, which may be as short as one thousandth of a second or as long as many years, and if we furthermore take into account that many experiments, especially those of a biological nature, are not absolutely repeatable, then we may come to the best practical solution in giving preference to the succeeding before the preceding measurements. This can be done by giving the individual measurements different weights according to our experience about the statistical behavior of measurements under improving conditions of exactitude and accuracy. That does not, of course, mean that we should discard less accurate measurements, moreover apply statistical methods, to obtain a maximum of reliable information from whatever the reading may be which we have made.

Francis Joseph Weiss

2000 37th Street N.W.
Washington, D. C.



Meetings

January

18–23. Pakistan Science Cong., 6th annual, Karachi. (Dr. Karimullah, Deputy Director of Industries, Punjab, Lahore, Pakistan.)

19–22. American Inst. of Electrical Engineers, winter general, New York City. (H. H. Henline, 33 W. 39 St., New York 18.)

22. Public Health Workshop on Dental Care in Industry, 2nd, New York City. (A. J. Asgis, 7 E. 42 St., New York 17.)

23–28. American Meteorological Soc., New York City. (K. C. Spengler, 3 Joy St., Boston 8, Mass.)

25–27. American Soc. of Heating and Ventilating Engineers, 60th annual, Houston, Tex. (A. V. Hutchinson, 62 Worth St., New York 13.)

25–27. Conf. on High Energy Nuclear Physics, 4th annual, Rochester, N.Y. (R. E. Marshak, Dept. of Physics, Univ. of Rochester.)

25–29. Inst. of the Aeronautical Sciences, annual, New York City. (S. P. Johnston, 2 E. 64 St., New York 21.)

28. American Federation for Clinical Research, annual, Portland, Ore. (I. S. Edelman, San Francisco Hospital, San Francisco 10, Calif.)

28–30. American Physical Soc., New York City. (K. K. Darrow, Columbia Univ., New York 21.)

28–30. American Assoc. of Physics Teachers, New York City. (R. F. Paton, Univ. of Illinois, Urbana.)

28–30. High Speed Computer Conf., Baton Rouge, La. (L. Megginson, Louisiana State Univ., Baton Rouge.)

29–30. American Geophysical Union, Los Angeles, Calif. (J. P. Marble, 3221 Macomb St., NW, Washington 8, D.C.

29–30. Conf. on Protein Metabolism, 10th, New Brunswick, N.J. (W. H. Cole, Rutgers Univ., New Brunswick.)

29–30. Western Soc. for Clinical Research, 7th annual, Portland, Ore. (H. N. Hultgren, Stanford Hospital, San Francisco 15, Calif.)

February

1–5. American Soc. for Testing Materials, spring, Washington, D.C. (R. J. Painter, 1916 Race St., Philadelphia 3, Pa.)

4. Instrument Soc. of America Regional Conference, 9th annual, New York City. (L. Butzman, 103 Park Ave., New York, N.Y.)

4–6. American Soc. for Quality Control, Textile Quality Control Conf., 4th annual, Raleigh, N.C. (D. Shainin, 70 E. 45 St., New York, N.Y.)

4–6. Inst. of Radio Engineers Conf. and Electronic Show, Tulsa, Okla. (D. R. Davis, P. O. Box 7221, Tulsa.)

5–6. Chicago Ophthalmology Soc., annual clinical, Chicago, Ill. (F. W. Newell, 950 E. 59 St., Chicago 37.)

7. Assoc. for Research in Ophthalmology, Midwest Section annual, Chicago, Ill. (F. W. Newell, 950 E. 59 St., Chicago 37.)

8–9. Conf. on Marine Corrosion Problems, Berkeley, Calif. (Dept. of Conferences and Special Activities, Univ. of California, Berkeley.)

13–14. American Educational Research Assoc., Atlantic City, N.J. (F. W. Hubbard, 1201 16 St., NW, Washington, D.C.)

14–16. National Soc. of College Teachers of Education, Atlantic City, N.J. (C. E. Eggertsen, School of Education, Univ. of Michigan, Ann Arbor.)

New Books Received

Fabricated Materials and Parts. Theodore C. DuMond. New York: Reinhold, 1953. v + 332 pp. Illus. $6.50.

Industrial Specifications. E. H. MacNiece. New York: Wiley; London: Chapman & Hall, 1953. xiii + 158 pp. Illus. $4.50.

German Readings in Science. For intermediate students. Nelson Van de Luyster. New York: American Book Co., 1953. viii + 280 pp. $2.25.

Cocoa: Cultivation, Processing, Analysis. Eileen M. Chatt. New York: Interscience, 1953. xiv + 302 pp. Illus. $8.50.

Physical Chemistry. 4th ed. For students of biology and medicine. David Ingersoll Hitchcock. Boston: Little, Brown, 1953. 266 pp. $5.00.

Research Operations in Industry. Papers delivered at Columbia University Conferences on Industrial Research. David B. Hertz, Ed. New York: King's Crown Press, 1953. xiv + 453 pp. $8.50.

Elementary Mathematics from an Advanced Standpoint. Vol. I, Arithmetic, Algebra, Analysis. Felix Klein. Trans. by E. R. Hedrich and C. A. Noble. New York: Dover, 1953. ix + 274 pp. Illus. Paper: $1.50; cloth: $3.25.

Managing Your Coronary. William A. Brams. Philadelphia: Lippincott, 1953. 158 pp. Illus. $2.95.

Orchids of Guatemala. Oakes Ames and Donovan Stewart Correll. Chicago: Chicago Natural History Museum, 1953. Fieldiana: Botany, Vol. 26, No. 2, 349 pp. Illus. Paper: $4.00; cloth: $5.00.

The Limits of the Earth. Fairfield Osborn. Boston: Little, Brown, 1953. x + 238 pp. $3.50.

The Protestant Credo. Vergilius Ferm, Ed. New York: Philosophical Library, 1953. xi + 241 pp. $5.00.

J. Robert Oppenheimer and the Atomic Story. J. Alvin Kugelmass. New York: Julian Messner, 1953. 179 pp. $2.75.

Recurrent Maladies in Scholarly Writing. Eugene S. McCartney. Ann Arbor, Mich.: University of Michigan Press, 1953. xiii + 141 pp. Illus. $2.50.

The Journals of Lewis and Clark. Bernard DeVoto, Ed. Boston: Houghton Mifflin, 1953. lii + 504 pp. $6.50.

Electricity and Magnetism. Edson Ruther Peck. New York: McGraw-Hill, 1953. xii + 476 pp. Illus. $7.50.

Philosophico-Scientific Problems. P. Henry Van Laer. Trans. by Henry J. Koren. Duquesne Studies, Philosophical Series 3. Pittsburgh, Pa.: Duquesne University Press, 1953. xi + 168 pp. Paper: $2.50; cloth: $3.25.

Educational Wastelands. Arthur E. Bestor. Urbana, Ill.: University of Illinois Press, 1953. 226 pp. $3.50.

Television Receiver Design, Monograph 2. Flywheel Synchronization of Saw-tooth Generators. Electronic Valves, Book VIIIB. Eindhoven, Holland: Philips' Technical Library; 156 pp. Illus. U.S. distr.: Houston, Tex.: Elsevier Press, 1953.

Nucleo-Cytoplasmic Relations in Micro-organisms. Boris Ephrussi. New York: Oxford University Press, 1953. vii + 127 pp. Illus. + plates. $3.75.

A Speculation in Reality. Irving F. Laucks. New York: Philosophical Library, 1953. 154 pp. $3.75.

Elementary Quantitative Analysis. Ralph L. Van Peursem and Homer C. Imes. New York: McGraw-Hill, 1953. xiii + 383 pp. $4.50.

Soil and Fertilizer Phosphorus in Crop Nutrition. W. H. Pierre and A. G. Norman, Eds. Agronomy Series, Vol. IV. New York: Academic Press, 1953. xvi + 492 pp. Illus. $9.00.

Galileo Galilei: Dialogue Concerning the Two Chief World Systems—Ptolemaic & Copernican. Trans. by Stillman Drake; foreword by Albert Einstein. Berkeley and Los Angeles: University of California Press, 1953. xxvii + 496 pp.

Newton's Philosophy of Nature. H. S. Thayer, Ed. New York: Hafner, 1953. xvi + 207 pp. $1.15.

Young People's Hebrew History. Louis Wallis. New York: Philosophical Library, 1953. ix + 117 pp. $2.50.

Dislocations in Crystals. W. T. Read, Jr. New York: McGraw-Hill, 1953. xvii + 228 pp. Illus. $5.00.

Chemistry of the Lanthanons. R. C. Vickery. New York: Academic Press; London: Butterworth, 1953. viii + 296 pp. Illus. $6.00.

From Fish to Philosopher. Homer W. Smith. Boston: Little, Brown, 1953. 264 pp. Illus. $4.00.

Existential Psychoanalysis. Jean-Paul Sartre. Trans. by Hazel E. Barnes. New York: Philosophical Library, 1953. viii + 275 pp. $4.75.

Terra. Gregor Lang. New York: Philosophical Library, 1953. xvii + 338 pp. Illus. $4.75.

Soils and Fertilizers. 4th ed. Firman E. Bear. New York: Wiley; London: Chapman & Hall, 1953. xiii + 420 pp. Illus. $6.00.

The Metabolism of Algae. C. E. Fogg. London: Methuen; New York: Wiley, 1953. ix + 149 pp. Illus. $2.00.

Roger Bacon: In Life and Legend. E. Westacott. New York: Philosophical Library, 1953. 140 pp. $3.75.

Advances in Virus Research, Vol. I. Kenneth M. Smith and Max A. Lauffer, Eds. New York: Academic Press, 1953. x + 362 pp. Illus. $8.00.

Nuclear Physics. W. Heisenberg. New York: Philosophical Library, 1953. ix + 225 pp. Illus. $4.75.

Scientific American Reader. New York: Simon and Schuster, 1953. xiv + 626 pp. Illus. $6.00.

Science in Alaska: 1951. Proceedings of 2nd Alaskan Science Conference, AAAS, Alaska Division. Dist.: Dr. Troy Péwé, Box 4004, U. S. Geological Survey, College, Alaska. xiii + 362 pp. $3.00.

Dictionary of Mysticism. Frank Gaynor, Ed. New York: Philosophical Library, 1953. 210 pp. $5.00.

Energy in the Future. Palmer Cosslett Putnam. New York: Van Nostrand, 1953. x + 556 pp. Illus. + tables. $12.75.

Reason and Nature. Rev. Morris R. Cohen. Glencoe, Ill.: Free Press, 1953. xxiv + 470 pp. $6.00.

The Psychology of Personality. Bernard Notcutt. New York: Philosophical Library, 1953. 259 pp. $4.75.

Communication and Persuasion. Carl Il Hovland, Irving L. Janis, and Harold H. Kelley. New Haven: Yale University Press; London: Oxford University Press, 1953. xii + 315 pp. $4.50.

A Field Guide to Rocks and Minerals. Frederick H. Pough. Boston, Mass.; Houghton Mifflin, 1953. xv + 333 pp. Illus. + plates. $3.75.

Man, Time, and Fossils. The Story of Evolution. Ruth Moore. New York: Alfred A. Knopf, 1953. xvii + 424 pp. Illus. + plates. $5.75.

The Disposal of the Dead. C. J. Polson, R. P. Brittain, and T. K. Marshall. New York: Philosophical Library, 1953. xii + 300 pp. $7.50.